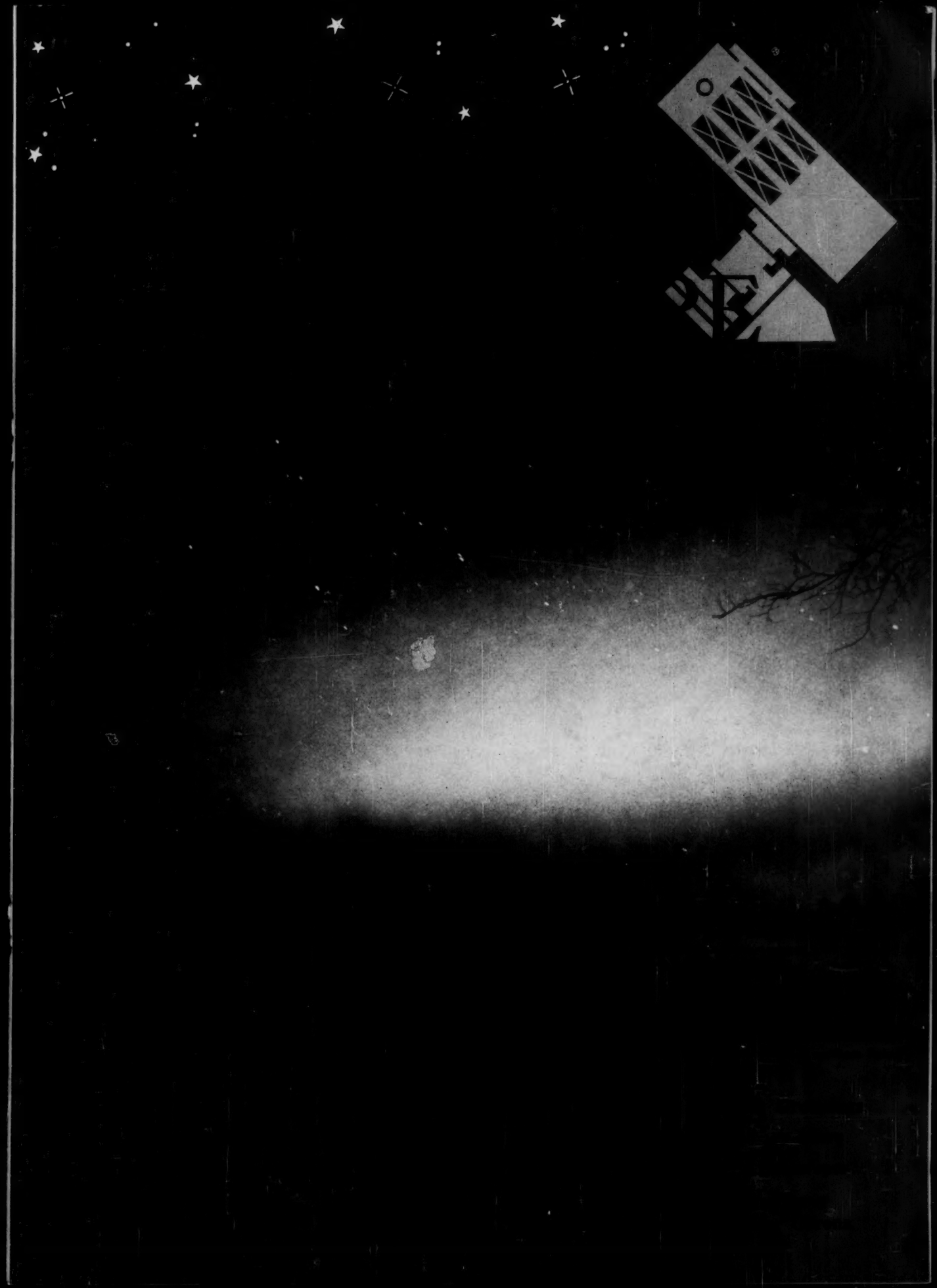

STAR-TESTED QUESTARS ARE USUALLY IN STOCK READY FOR IMMEDIATE DELIVERY, FROM $995. TERMS ARE AVAILABLE. LET US SEND YOU THE QUESTAR BOOKLET.

Here 50 finished Questar bases are having legs fitted to them by Peter Dodd and James Reichert of our staff. They are choosing legs at random from a large supply, selecting one for the center, which will be adjustable by means of a telescoping smaller tube, and then choosing a pair, each one of which will fit both holes in the side of the base with just the proper feel. And feel is the right word to use, for we take leave of measurements at this point and work for the fit that feels just right.

We make a quantity of 1875 legs before we finish any holes in the base castings. The first step is to select drawn aluminum tubing at the Philadelphia warehouse of the metals supplier. We accept only those tubes whose diameters, including ovality, vary less than .003 inch. The lengths are then shipped to the Micromatic Company of Trenton, New Jersey.

Micromatic cuts them into short pieces and chamfers both ends inside and out. Then they centerless grind the entire outside surface to a tolerance of only plus or minus .0001 inch. One ten-thousandth inch. The group is then shipped to Pottstown, Pennsylvania, for a uniform, heavy anodizing, or sapphire plating, by the electrolytic method. This coating is actually quite thin, but very hard and durable for it is, being sapphire, of the corundum family. The 625 sets of legs, each alike in size to all the others within .0002 inch, are finally shipped to our factory at New Hope, where we make some parts completely and finish up others.

Meanwhile Micromatic has milled a long slot in 625 smaller tubes which slide inside the center tube and can be clamped at various degrees of extension. These smaller tubes do not need a close fit. A half-round block of milled aluminum alloy goes inside the slotted tube. One-half turn of a knurled knob will lock both tubes securely. Neither knob nor sliding tube can ever fall out to get lost.

Questar's base casting is made by the Boose Aluminum Foundry of Reamstown, Pennsylvania. The alloy used is Alcoa No. 356 tempered to the T-6 condition. Because it contains 7% silicon it is exceptionally free-flowing in the molten state. It has the virtue of great resistance to the acids of perspiration or the corrosive salts of sea water, and retains its polish very well. We use the piece, therefore, without paint or surface treatment. If scratched or nicked, one may always polish out the defect and renew the surface luster. The workmen at Boose pour these castings one at a time into moulds prepared from metal matchplates instead of wooden patterns.

After the tempered sand castings have been cleaned by sand-blasting, they go to Gerald Fegley's shop in Pottstown, where he turns off almost one-half the metal in accurate machining. When turned to proper size on the engine lathe, Mr. Fegley himself puts them one by one in a large fixture which supports the piece and serves as guide while several holes are drilled, later to be tapped for fastening screws, and the three leg-holes are bored a trifle undersize. We have by this time sent several sample legs to Fegley and he has prepared a reamer and burnishing tool to ream each hole and burnish it to a mirror finish of exactly the desired size. When each piece is finished to his satisfaction, it is a handsome thing with no rough edge inside or out. Each is individually wrapped and shipped to us.

Then, as you see, the work of hand fitting each leg by selection begins. This job takes two men a day and a half to do 50 sets. The inherent ovality of tubing is what makes selection necessary within the .0002-inch range of tube diameters.

Finally, butyl rubber tips are cemented into all three legs of a set, the adjustable leg finished, and each one placed in its individual pouch on the door of an English leather case, which then is tagged with a numbered card for one specific base.

There are no secrets about making the best telescope in the world. We try to make every single part just as fine as possible.

QUESTAR

NEW HOPE, PENNSYLVANIA

Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

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Vol. XXII, No. 6 DECEMBER, 1961

CONTENTS

COVER: Facing northward across Union Lake in Millville, New Jersey, James A. Loudon observed the great aurora of September 30, 1961. This quiescent form was photographed at 8:53 p.m. Eastern standard time, on Kodak Tri-X film exposed for one minute. The auroral glow stretches across the Big Dipper, whose bowl is just under the tree branch at right. Low-lying fog on the lake did not obstruct Mr. Loudon's view of the sky. (See page 322.)

NEWS OF FOUR COMETS 311
SIDELIGHTS ON VARIABLE STAR OBSERVING — Clinton B. Ford 312
IAU SYMPOSIUM ON VISUAL DOUBLE STARS — Joseph Ashbrook 315
WEATHER PROSPECTS FOR THE ECLIPSE IN FEBRUARY — Edward M. Brooks 318
COMPACT PLANETARY GROUPINGS — Jean Meeus 320
PICTURES OF THE SEPTEMBER 30TH AURORA 322
SOME MASSIVE BINARY STARS — Otto Struve 323
TWO GIANT RADIO TELESCOPES 326
PASSAGE OF A FLARE SPRAY THROUGH THE SOLAR CORONA — Frank Q. Orrall and Henry J. Smith 330

AMATEUR ASTRONOMERS 336
A Teaching Observatory in the Netherlands
The AAVSO Celebrates Its 50th Anniversary

ASTRONOMICAL SCRAPBOOK 331
The Great September Comet of 1882

BOOKS AND THE SKY 351
Structure of the Moon's Surface
Methods of Celestial Mechanics
Stellar Atmospheres

CELESTIAL CALENDAR 366

GLEANINGS FOR ATM's 359
A Prize-Winning Gregory-Maksutov Telescope
The Use of a Barlow Lens

NEWS NOTES 328

OBSERVER'S PAGE 344
Observing Venus near Inferior Conjunction
Rilles in Palus Epidemiarum
Deep-Sky Wonders

OBSERVING THE SATELLITES 332

QUESTIONS 325

SOUTHERN STARS 368

STARS FOR DECEMBER 369

INDEX TO VOLUME XXII ..... Center

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Second-class postage paid at Boston, Mass.

Subscription: $5.00 per year in the United States and possessions; $9.00 for two years; $13.00 for three years. To Canada, Mexico, and all countries of the Pan American Postal Union, $6.00 for one year; $11.00 for two years; $16.00 for three years. To all other foreign countries, $7.00 for one year; $13.00 for two years; $19.00 for three years. Canadian and other foreign remittances should be made in United States currency. Single copy 50 cents. *Back issues:* November, 1957, to present, 50 cents per copy. Vols. I through XVI (November, 1941, to October, 1957), order from Walter J. Johnson, Inc., 111 Fifth Ave., New York 3, N. Y.

All notices of change of address must be sent one month in advance and accompanied by old and new addresses. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. Return our bill form with remittal payment. Circulation manager, Nancy R. Bolton. Office staff: Sarah E. Bulger, Virginia K. Cox, J. Caroline Nason, Mary Silva, John Simmons, Helen B. Sniegiecki, Stacia Strong.

Editorial and advertising offices: 49-50-51 Bay State Rd., Cambridge 38, Mass. Phone UN 4-7360. Assistant editors: Gail C. Parker, advertising; William E. Shawcross (on leave); Raymond N. Watts, Jr., features. Art assistant, Willem P. Schrauwen. Advertising rates are listed in STANDARD RATE AND DATA SERVICE, or sent upon request; closing date (except covers) is 20th of second month preceding date of issue. Unsolicited articles and pictures are welcome, but prompt attention and return are not guaranteed.

The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

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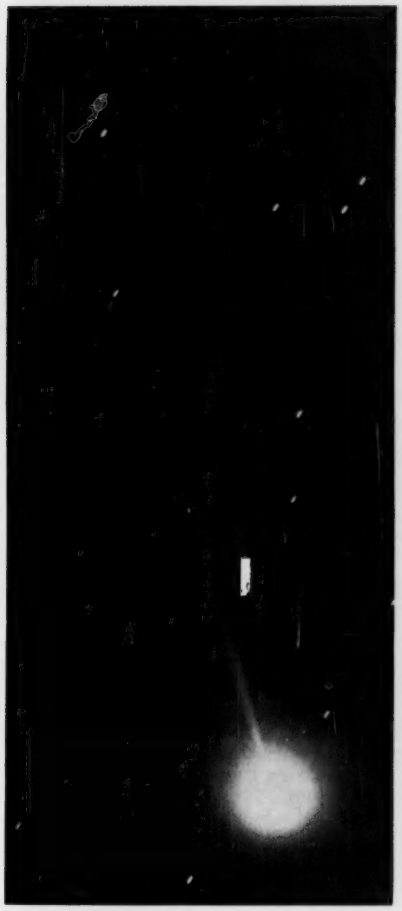
News of Four Comets



A brilliant coma and a narrow straight tail were features of Comet Seki on October 18, 1961, when this 25-minute exposure was taken by Elizabeth Roemer. Official U. S. Navy photograph.

ON OCTOBER 10th, Tsutomu Seki at Kochi, Japan, discovered an 8th-magnitude comet near Beta Leonis. Designated 1961f, it was soon observed from many countries, estimates of its total magnitude ranging from 5 to 8. A tail four degrees long was noted on the 14th by P. Ahnert at Sonneberg Observatory, East Germany.

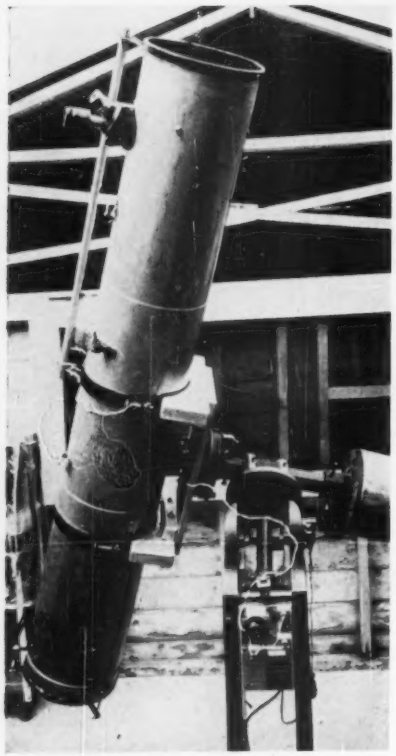
On October 25th, the total magnitude of Comet Seki was estimated by Elizabeth Roemer at 6.5, as seen in 7 x 50 binoculars. That same night the nuclear condensation of the comet was of magnitude 13 on short-exposure photographs she took with the 40-inch reflector of the U. S. Naval Observatory at Flagstaff, Arizona.

Orbit calculations indicate that the comet was at the perihelion point of its orbit on the day of discovery. Receding from the sun, Comet Seki passed nine million miles from Earth on November 15th,

(Continued on page 329)

Sidelights on Variable Star Observing

CLINTON B. FORD, *American Association of Variable Star Observers*



The author's 10-inch reflector has a standard German-type equatorial mounting. The lensless finder can be seen left of the telescope tube, and the temperature controls for the eyepiece heater are in the center of the pier. Photograph by R. Newton Mayall.

"WELL, it looks like stars tonight!" Coming on a clear afternoon after several cloudy days, these words are music to the ears of amateur astronomers. Thoughts then run: "I hope there's nothing else *really* important I've promised to do tonight"; "How late can I observe and still seem awake tomorrow?" "What's the phase of the moon?" and so on, until the final question, "What to observe?"

Members of the American Association of Variable Star Observers never have trouble with that last question. At any time of the night and in all seasons there are plenty of variable stars to study. With a 6-inch telescope or larger, the contrary problem is usually more to the point. There are more stars to observe than time will allow, and a selected list has to be made in order not to waste time on brighter variables that will be covered by observers with smaller instruments.

After the sun sets, every experienced variable star observer has his own system of procedure, limited by his instrument and location. The old adage that some of the best work is done with very modest equipment is just as true today as in the days of Argelander. What count most are patience and resourcefulness — the ability to make the best use of whatever equipment is available.

My own observatory housing a 10-inch reflector may not appear modest, yet the instrument has no circles; the mounting, except for the pier castings, is a hodge-podge of odds and ends which were picked up from a junk pile; the gear and electric drive are not precise, although adequate for following a variable star field long enough to make a brightness estimate; there are no finders except for what John Ruiz calls my "bean shooter," an open aluminum tube for sighting field stars shown on AAVSO charts; and the primary mirror is plate glass rather than pyrex. On the other hand, some apparently superfluous items are really vital for variable star work, such as a three-way rotating eyepiece holder for rapid transfer from low to high power when estimating faint variables, oculars of highest quality, and a temperature-controlled heating coil to prevent dew and frost from forming on the eyepiece lenses.

Except for very large instruments, a dome is mainly a decorative feature. Certainly an active variable star observer doing visual work is far better off with a hand-operated sliding-roof observatory, regardless of how it looks. Much time can be lost in turning a dome, and in order to proceed rapidly from one star to another, large areas of the sky must be visible. Domes are fine for lunar and planetary work, of course, serving most effectively as windshields.

Why no circles? Many experienced amateur observers who install circles on their mountings at considerable expense soon find they don't use them very much — unless, of course, they have also obtained a costly dome which shuts out so much of the sky that circles are a necessity. Keep everything as simple as possible, and don't add "improvements" unless they serve some practical purpose.

AAVSO headquarters issues basic prediction sheets that simplify the programming of observations, but in order not to duplicate estimates of one long-period star to the neglect of others it is a good idea to maintain a monthly check list

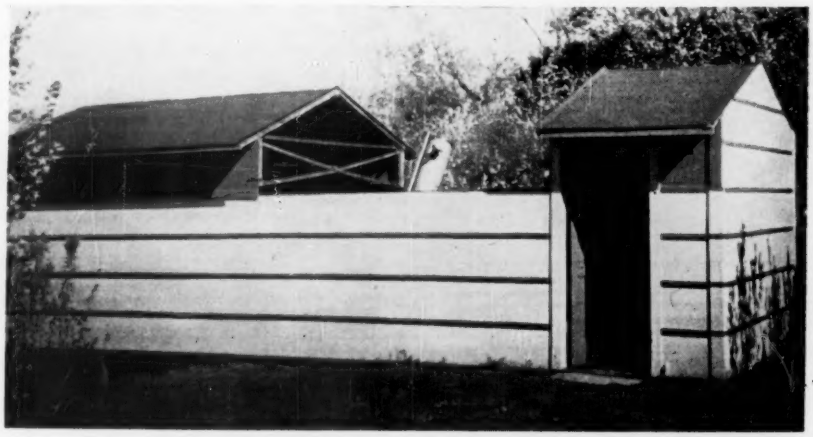
AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

VARIABLE STARS ..... MONTHLY CHECK-OFF LIST

FOR THE MONTH OF May 19 59

R. A. Hour	First Time	Second Time	NOTE	All Possible
0				
1				
2				
3				
4				✓
5	✓		N. only	✓
6	✓		" "	✓
7	✓		~~N. only~~	✓
8	✓		~~" "~~	✓
9	✓	✓	~~Three W Cnc only~~ OK	
10	✓			✓
11	✓			✓
12	✓	✓		
13	✓	✓		✓
14	✓	✓	~~Portion, napoleons~~ OK	
15	✓			✓
16	✓		OK —	✓
17	✓	✓	~~N. only~~ OK	✓
18	✓		~~North only~~	
19	✓		" "	
20	✓		~~— "~~	✓
21	✓		~~SS Cyg only~~ OK	✓
22	✓		~~North only~~	
23	✓		" "	

A monthly check list, shown as completed by the author for May, 1959. Items subsequently crossed off were to indicate the need of further work on a particular segment of right ascension.

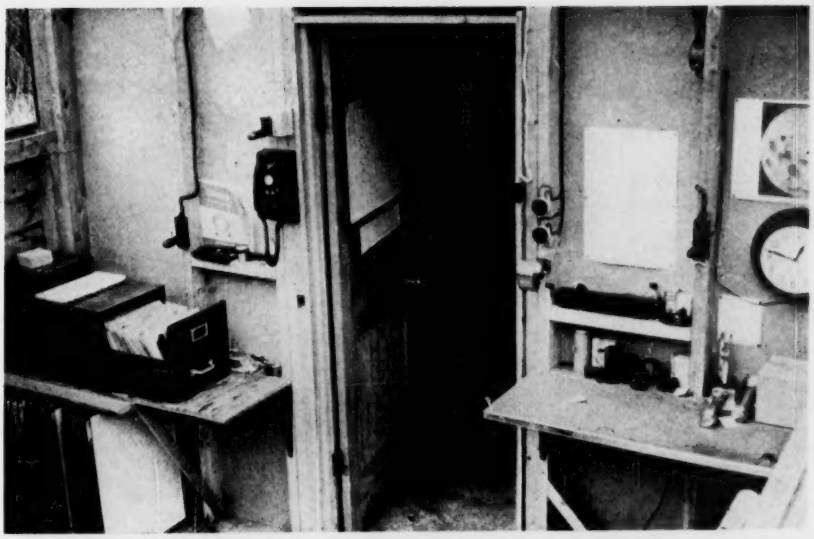


The roll-off roof of Clinton B. Ford's observatory in Suffield, Connecticut, allows him to see most of the sky rather than the limited section that can be viewed through the slit of a dome. The small workshop at the right houses observing records, charts, and accessories, and can be heated in winter.

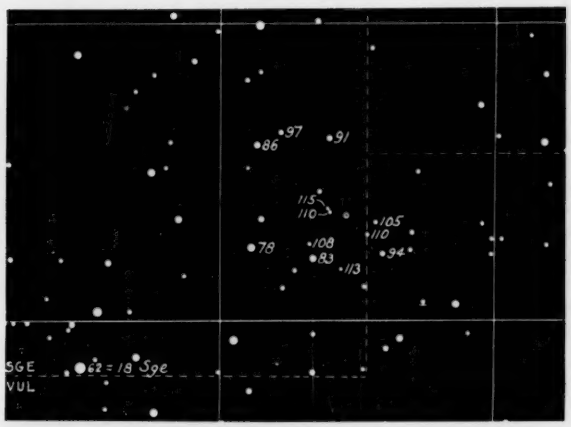
like the one illustrated. As each hour of right ascension is "worked" during the month (perhaps only partially at first for lack of time), it is checked off in the "first time" column, and notes are made. Then if there is an opportunity to return to that region later in the month, the stars originally missed are observed, and the "second time" or "all possible" columns are checked. This record prevents wasteful duplication of effort and allows the observer to see at a glance where each night's observing should begin.

The interior view of my observatory shows at the lower left a convenient method for mounting and filing a set of Skalnate Pleso *Atlas of the Heavens* charts on $\frac{1}{8}$-inch-thick pressed-wood board. Thus, they are readily accessible and can be quickly hung on a wall for reference when locating the brightest field (or key) stars on AAVSO charts. Variables too faint to be shown on the atlas charts are penciled in, and key charts can usually be found for their fields.

On the shelf above the chart rack is a file box containing standard AAVSO and other detailed charts. Many observers, especially those with large instruments, prefer to file their charts by constellations in order to avoid as much as possible moving telescopes and domes. I have tried this, but always go back to filing by increasing right ascension.



The interior work space of the Ford observatory, showing at the left a file drawer for finder charts; on the shelf beneath are board-mounted sheets from the Skalnate Pleso atlas, which can be hung on the door when in use. On the right shelf, beneath the clock, is a box for observing records on five-by-eight cards. Photograph by R. Newton Mayall.



A portion of a chart prepared by the American Association of Variable Star Observers. It is designed to aid the user in locating the variable and estimating its brightness. In this case the star to be observed is V Sagittae, represented by the circle to the right of center. The variable is subject to unexpected changes in brightness superimposed on its cycle of some 530 days (see September, 1959, issue, page 632).

A record should be kept for each night's work. No two observers use the same form, yet all forms should contain the same basic information. The five-by-eight-inch sample card shown here is the result of revisions over a period of about 30 years, and is as satisfactory as any. It can be used on both sides, and holds 32 estimates. A new card is used for each observing date, and at the end of the month the necessary data are transferred to standard AAVSO report sheets for mailing to headquarters.

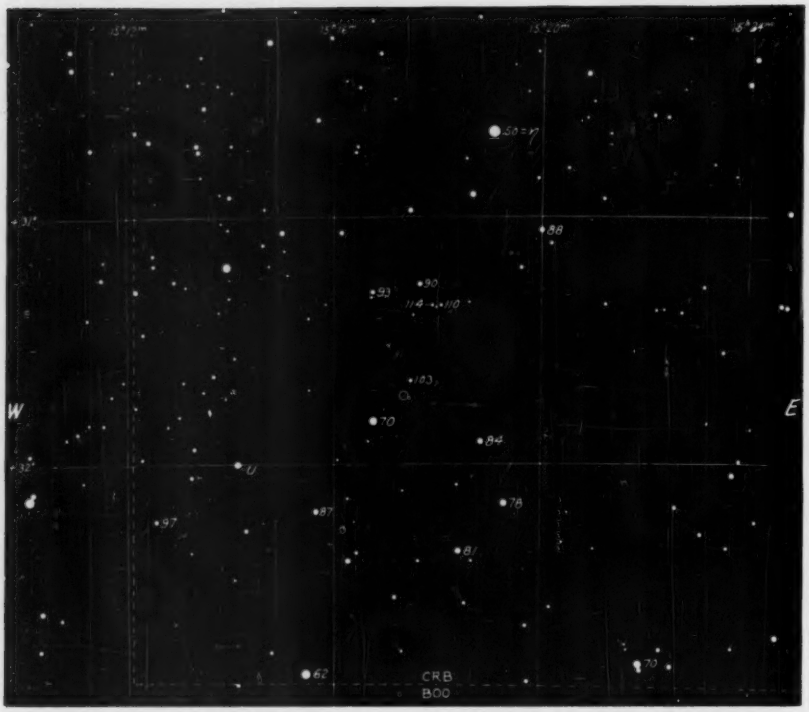
An annoying problem is that of illuminating charts while at the eyepiece. Many elaborate chart holders with lights have been built, but most of them sooner or later are discarded in favor of the ordinary two-cell flashlight fitted with a red filter. Shining the red light through the blue-printed chart from the rear is often much better than using direct illumination, and the flashlight should not have a spot reflector and lens. Diffuse reflecting flashlights are not so common in hardware stores as they were some years ago, but are still available.

As described in the AAVSO *Manual for Observing Variable Stars*, making an observation consists of three steps: locating the field with the telescope, identifying the variable, and finally estimating its magnitude in terms of suitable comparison stars. The initial step is where beginners frequently give up and go back to ordinary stargazing, or study of the moon and conspicuous planets. I've found

DATE May 4, 1959 J. D. 36693 REPORT SENT IN 6/5/59
INSTRUMENT 10 inch Suffield MOON None — SKY Perfect, but w/ aurora N. Temp. 520-480

No.	TENTH	ESTIMATE	COMP. STARS	DESIGNATION	STAR	NOTE
1	0.6	12.2	12.0 - 12.8	141567	U UMi	
2		9.0	9.2 - 8.4	142584	R Cam	
3		<14.3	— - —	170627	RT Her	
4		12.2	12.0 - 12.3	171723	RS Her	
5		10.9	10.6 - 11.3	175458a	T Dra	
6		11.6	11.3 - 11.8	175458b	UY Dra	
7		13.9	13.5 - 14.2	175519	RY Her	OK!
8		11.4	10.8 - 11.7	175654	V Dra	Seque.?
9		13.3	12.8 - 13.5	172809	RU Oph	
10		12.3	12.5 - 11.8	175111	RT Oph	Aurora interfering
11		10.9	11.0 - 10.4	180531	T Her	
12	0.7	9.4	9.5 - 9.2	180565	W Dra	Sequence?
13		10.8	11.0 - 10.7	180666	X Dra	Tough!
14		13.0	12.9 - 13.3	181103	RY Oph	Seque.?
15		11.4	11.1 - 12.1	181136	W Lyr	

One of Mr. Ford's record cards, reduced in size for reproduction here. The first two observations, of circumpolar variables, completed the coverage of 14 hours in right ascension for May, 1959. As 15^h and 16^h had already been finished for the month, the night's new work began with 17^h.



This AAVSO "b" chart shows the surroundings of the long-period variable S Coronae Borealis, which is marked by a circle at the center. As the star changes between magnitudes 7 and 13 in about 360 days, it is compared with other stars, labeled by their magnitudes with decimal points omitted. The star 103 just above S is of magnitude 10.3, for example.

that there are four simple rules for success in locating a field: 1. Use the lowest power available, giving the widest possible field of view. 2. Start with an "easy" star, such as R Leonis or R Scuti or R Ursae Majoris, almost always bright telescopically and with bright comparison stars near it. 3. Sight by naked eye along the length of the telescope tube and point it to the approximate position of the variable in the sky as determined from a star map. 4. Be sure to hold the map with its south toward Polaris, not just in a general north-south direction, for comparison with a telescopic view.

Initial recognition of a charted star configuration depends largely on preconceived notions of how big the configuration should look, considering the size of the field of view. Such mental pictures can be very misleading, so it is helpful at first to draw a small circle on the atlas chart, centered on the variable's position, of diameter equal to the field of view. This gives a definite idea of what to look for, but remember that the telescope inverts what is shown in the atlas.

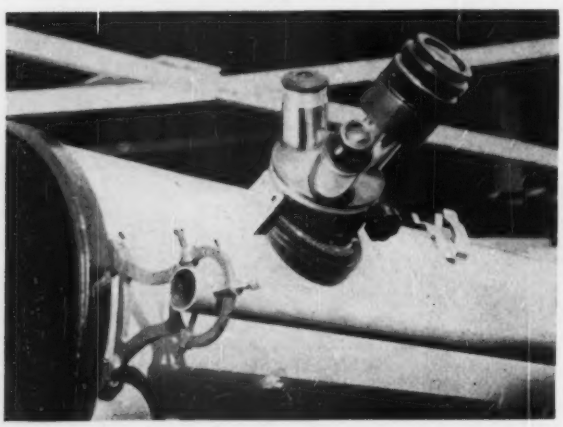
If the variable is too faint to be seen at the time, be careful not to mistake a nearby comparison star for it. The old rule that the variable can be spotted by its red color is not very reliable, since many do not look red, especially when faint.

One source of discouragement is to have located and identified the variable, only to find that suitable comparison stars are outside the field of view. Use a lower-powered eyepiece if one is available, or make the best of it by moving the telescope back and forth to bring the variable first and then the comparison stars into view, retaining a mental impression of the brightness of each while moving the instrument. This is where a solid mounting with smoothly working parts is a great asset.

Some magnitude sequences shown on charts can be annoyingly deficient and even appear incorrect at times. Here again, don't give up; do your best and note in the observing record, "Sequence?" There are over 1,000 different AAVSO charts, and nobody proposes that they are all free from errors.

The most interesting variables are the unpredictable ones, of course, and a real prize for a night's work is to catch SS Cygni, U Geminorum, or some other irregular star near maximum or behaving abnormally. Many persons not astronomically inclined like to ask, fairly enough, "But what do you *do* when you look at stars?" A good answer is, "I look at the peculiar ones!" With irregular stars, there is a special satisfaction in obtaining a good estimate, since it is certain the information will be especially valuable, even if duplicated by another observer thousands of miles away. Flare stars are the "special specials," but monitoring them is a tedious job and only for observers with iron patience.

If clouds or approaching dawn do not cause it, the end of a night's work is usually signaled by fatigue and difficulty in concentrating on star magnitude values. Also there is the number one enemy, Time, who keeps nagging, "Think of all the things you have to do tomorrow. Better quit and get to bed." No matter how late the hour or how great the fatigue, before closing up shop just gaze with your naked eye at the sky for about a minute, forgetting all else. Your admiration for the sheer beauty of the stars will be wonderfully renewed and strengthened by the thought that you have that night made a small contribution to man's knowledge of them.



A closeup of the revolving turret for three eyepieces on the author's 10-inch reflector. The eyepieces are a wide-angle Erfle of 1½-inch focal length, a Higgins ¾-inch orthoscopic, and a Brandon 12-mm. Note the three-way adjustment of the support for the upper end of the "bean-shooter" finder or sighting tube.

ANNE S. YOUNG DIES

One of America's best-known women astronomers, Anne Sewell Young, died in August at the age of 90. She had lived for many years in California, following her retirement as professor of astronomy at Mt. Holyoke College, South Hadley, Massachusetts.

Born in Wisconsin, she received her doctorate in astronomy from Columbia University in 1906. She taught astronomy at Mt. Holyoke from 1899 to 1936, and was director of its Williston Observatory for the same period. Dr. Young was a former president of the American Association of Variable Star Observers and an active observer of occultations of stars by the moon. Many of the women astronomers in this country received their first professional training as her students.

IAU Symposium on Visual Double Stars

JOSEPH ASHBROOK, *Harvard College Observatory*

PROBABLY more stars are members of double or multiple systems than are single, the isolated stars being a minority. Moreover, the amount of useful information that observation can gain from a star is much increased if it is a member of a binary system. But the number of astronomers active in this important field is very small.

This raises many urgent problems: With the limited manpower available, what types of research rate high priority? What new observing methods should be put to use? What observations must be made now to meet future needs? And how can more new observers be recruited?

Answers to such questions were sought at a two-day closed meeting of 29 leading double star specialists, held in August at Berkeley, California. This symposium was under the auspices of the International Astronomical Union, with financial support from the National Science Foundation. Peter van de Kamp, director of Sproul Observatory, organized the gathering and led its discussions.

The participants came from 10 countries. Some, like G. Van Biesbroeck of the United States and W. H. van den Bos from South Africa, are veteran observers of visual pairs with the filar micrometer. K. A. Strand (U. S. A.) and Ejnar Hertzsprung (Denmark) are specialists in precise photographic measurements. The active new school of French workers with double-image micrometers was represented by P. Muller, and South Africa's W. S. Finsen brought his experience in interferometer observing to the meeting. R. M. Petrie (Canada) is a spectroscopist who measures radial velocities of visual binaries. Two of the most active participants, W. P. Bidelman and Armin Deutsch (U. S. A.), expressed the viewpoint of astrophysicists who use double star data.

W. S. Finsen has been an active observer of southern double stars for over 30 years in South Africa. He is the inventor of an eyepiece interferometer that has proved very effective for the discovery and measurement of extremely close pairs.

The opening session was devoted to a lively exchange of ideas on the purposes of double star observations. Olin Eggen (then of Greenwich Observatory) emphasized the value of visual binaries as a source of information on the masses of the stars; if the orbit of a binary is found, together with its distance from us, the sum of the masses of the components becomes known. Usually most of the uncertainty in a mass determination comes from low accuracy in the distance. For binaries with large parallaxes, this uncertainty is considerably reduced. Hence emphasis should be put on observing nearby binaries in order to improve our knowledge of stellar masses.

Dr. Van Biesbroeck stressed that any substantial increase in the number of known orbits will require many more observations of very close, short-period pairs, for which big telescopes are necessary. Even for longer-period systems, large apertures are needed for the critical observations near periastron. As one instance, he mentioned Mira Ceti, an important binary which in the last few years has begun to close in rapidly.

Great reflectors are well suited for measurements of difficult doubles, as Dr. Van Biesbroeck's experience with the 82-inch telescope at McDonald Observatory has proved. In double star work, there is no difference between the optical performance of a refractor and a reflector of 50-per-cent more aperture, noted Dr. van den Bos. Thus the world's largest refractor, the 40-inch at Yerkes Observatory, can be matched by a 60-inch reflector, a modest size nowadays.

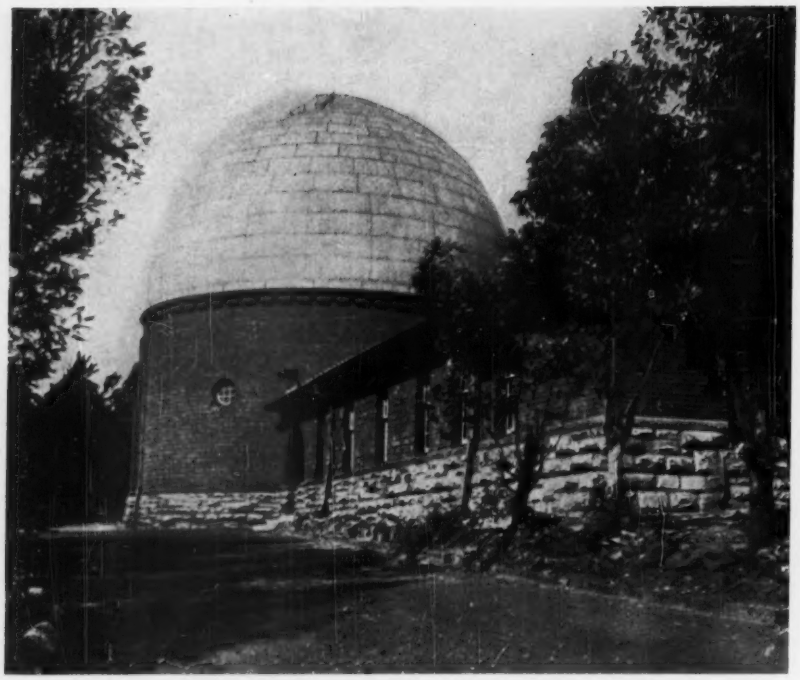
Dr. Finsen told that the Republic (formerly Union) Observatory at Johannesburg has the disk for a 74-inch mirror, and he hopes that the finished instrument will be used for double stars. The pressure for observing time on existing large reflectors is so great that at present none of them is being used for micrometer measures of doubles. One of the recommendations adopted by the symposium was that experienced double star observers be given access to such instruments.

Wide double stars are becoming increasingly useful to astrophysicists. For example, the components of a very open binary should have practically equal radial velocities, because the orbital motions are slow. If the two stars are of very different spectral types, they afford a much-needed test of whether velocity measurements of stars with different spectra are strictly comparable, Dr. Petrie pointed out.

Peter van de Kamp is director of Sproul Observatory at Swarthmore, Pennsylvania. He and his staff have determined the parallaxes and mass ratios of many visual binaries. One Sproul specialty has been the discovery of astrometric binaries — cases where the variable proper motion of a star indicates the presence of an unseen stellar companion.

Furthermore, a distant physical companion to a star of astrophysical interest can supply valuable information. Thus R Hydrae has a faint secondary discovered by G. W. Hough; study of its spectrum and brightness could tell us the absolute magnitude of the primary star, a long-period variable. The symposium participants agreed that double stars of which one component is variable are particularly worthwhile objects for measurement. A new catalogue of such pairs is being prepared at Moscow, said P. G. Kulikovsky.

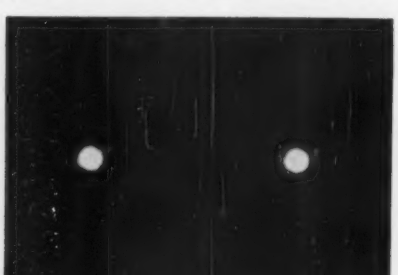
One session of the symposium was devoted to techniques of measuring visual doubles. In recent years, many observers have abandoned the classical filar micrometer for the double-image micrometer developed by Dr. Muller. The special advantage of the new design is that it allows much more reliable measurements



The Republic Observatory at Johannesburg, South Africa. Inside the dome is the 26½-inch refractor, which since its erection in 1925 has been devoted almost exclusively to double star work, by R. T. A. Innes, W. H. van den Bos, and W. S. Finsen. Many of the most interesting southern binaries have been discovered with the aid of this fine instrument.

of separation in close pairs, P. Couteau of Nice Observatory in France told the gathering.

For doubles wider than about two seconds of arc, photographic measurements reign supreme. Nevertheless, said Dr. Strand, the accuracy of this method is essentially the same as when Dr. Hertzsprung devised it 47 years ago. The improvements have been chiefly in economy of effort. In modern work, automatically spaced images are made on a multiple-exposure plate taken with a photoelectrically guided telescope; the plate measurements are recorded in digital form on punch cards and the reductions are performed by machine, saving much time.



These pictures of the binary star 85 Pegasi were made by photographing the phosphor screen of a cascaded image tube attached to a 24-inch refractor, on August 15, 1959. The 9th-magnitude companion is clearly separated from the brighter star, although it is three magnitudes fainter and only 0.8 second of arc away. Photograph from Lowell Observatory.

There has been some misunderstanding about the capabilities of the interferometer method of observing very close doubles, Dr. Finsen explained. For its effective use, large reflectors are recommended, but they have never been so employed except in pioneer work at Mount Wilson Observatory about 40 years ago. The interferometer is not suited for small apertures, because of danger in misinterpreting the delicate pattern of interference fringes overlying the star image. Even the 26½-inch refractor used by him is a small instrument for interferometry, said Dr. Finsen.

An important breakthrough described by John Hall, Lowell Observatory, is an image-tube method for obtaining photographs of close and unequal pairs, previously observable only visually. The limit of photographic resolution is imposed by the earth's atmosphere; even in a few seconds of exposure good seeing is averaged with poor to give enlarged, blurred images. Use of an image converter permits much shorter exposure times, so that brief moments of excellent seeing can be exploited.

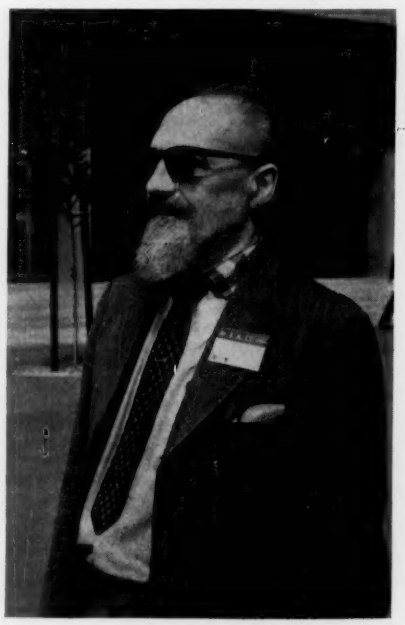
Dr. Hall's experiments are being made in collaboration with Laurence W. Fredrick, and are a continuation of the work described in SKY AND TELESCOPE for March, 1959, page 255. By attaching a Barlow lens to the 24-inch Lowell refractor, they obtain a plate scale of four seconds per millimeter. At the focus, light from a double star falls on the cathode of a cascaded image tube, the following parts of the optical train being a relay lens and a movie camera. The arrangement gives a 100-fold gain in speed, and a star of magnitude 7.5 can be recorded at 16 frames per second, through a deep green filter.

The success of this method was demonstrated by pictures of such difficult doubles as 51 Aquarii (separation 0.5 second) and 85 Pegasi (0.8 second), which were exhibited at the symposium.

Credit for this advance belongs also to J. Rösch, of Pic du Midi Observatory in France, where a parallel development is under way. At the Pic, a Lallemand electronic camera is being used on the 24-inch refractor for photography of close double stars. Dr. Rösch had with him at the meeting a picture of one double whose components were as little as 0.23 second apart!

A striking peculiarity of double star work, shared by few other branches of astronomy, is that the observations made over a century ago still have great importance, for example in orbit computations. The bulk of useful measurements is enormous, and there are about 60,000 known doubles. Hence the problem of making the data available in convenient form is formidable.

H. M. Jeffers of Lick Observatory was able to report that a solution is nearly achieved. He has been engaged in the preparation of a new *Index Catalogue* of doubles, which will contain basic data for every known pair. This will supersede R. G. Aitken's catalogue of 17,000 systems, already 35 years old. Dr. Jeffers has compiled the material for stars visible from northern latitudes, and Dr. van den Bos,



W. H. van den Bos, having retired after many years as director of the Republic Observatory, is now working with H. M. Jeffers at Lick Observatory on the cataloguing of double stars.

now at Lick Observatory, is working on the portion covering the sky from declination −19° to −90°. It is planned to publish the *Index Catalogue* in book form.

This will not be feasible for the much larger *Observation Catalogue* also being undertaken by these two astronomers. This listing of all double star measurements is too huge to be printed; instead it will be issued in the form of punch cards. Probably four sets of cards will be prepared, to be deposited in different countries.

One important class of double star falls outside the scope of these listings — wide pairs of faint objects with common proper motions. For many years W. J. Luyten of the University of Minnesota has been searching for these on photographs, with the aid of the blink microscope. He reported to the meeting that his extensive catalogue of common-proper-motion pairs is now complete in manuscript form.

There was a stimulating exchange of views among the assembled experts regarding plans for future work. Dr. van den Bos urged a repetition of the great surveys for the discovery of new pairs, such as were carried out by Aitken, W. J. Hussey, and himself some decades ago. None of these historic surveys was complete, for many interesting binaries were too close to be recognized on the date of examination, and many other doubles were simply overlooked.

Greater immediate returns would come from systematic searches among special classes, such as the naked-eye stars, or those with large proper motions or parallaxes. Dr. Finsen recommended that someone extend his interferometer survey of bright southern stars to the northern hemisphere, and that a special examination be made with large telescopes of the approximately 1,000 stars known to lie within 20 parsecs of the sun. One example of a special survey was Charles E. Worley's inspection of 750 dwarf *M*-type stars at Lick Observatory, resulting in the discovery of 27 new pairs.

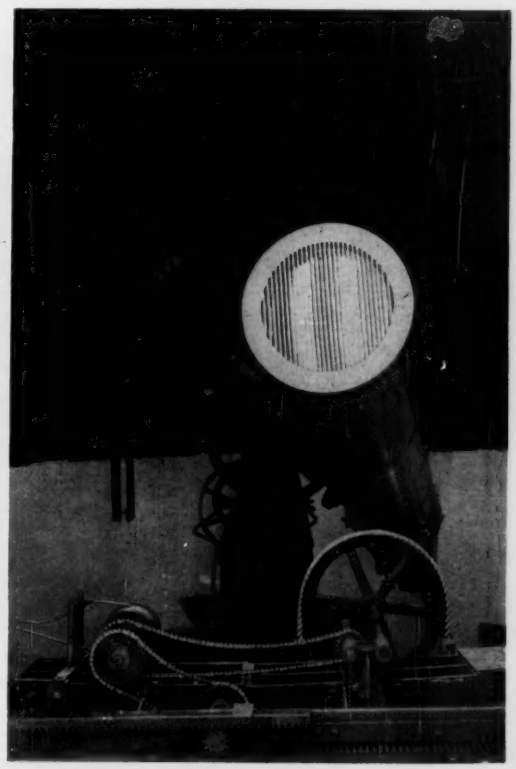
Many suggestions for studies of known doubles were aired. Dr. Kulikovsky of Moscow made a request for many more observations of systems that contain variable stars. Dr. Luyten emphasized the need for work on pairs in which one component is a white dwarf, in order to gain information about the masses of these important objects. There are only three well-studied binaries with white dwarf members, he pointed out, but Sirius B is a freak and Procyon B is too faint to do much with, leaving o^2 Eridani B as the lone case of a white dwarf with a reliably known mass.

S. Arend, of the Royal Observatory, Brussels, Belgium, has made many measures of doubles with its 15-inch refractor. Well known for his comet and asteroid work, he was co-discoverer of bright Comet Arend-Roland 1956h.

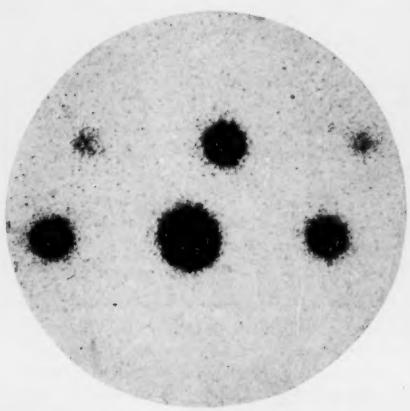
Prospects are bright for valuable results from the present programs of photographic measurements of wide, slow-moving binaries. Even though the observations extend over only short orbital arcs, they suffice to permit determination of dynamical parallaxes and statistical studies of stellar masses. The precision of photographic observations is so high that a reliable orbit can be calculated when the companion has completed only a fraction of its circuit, provided that this arc shows strong curvature.

In the double star work of the future, radial velocity observations will play an increasingly important role. At the Dominion Astrophysical Observatory, regular radial velocity measurements are being made of about 25 selected binaries. Eventually, the combination of visual or photographic results with spectrographic ones should yield highly reliable masses and distances.

One way to convey the impression made by the 1961 Berkeley double star symposium is to glance back at this branch of astronomy in, say, 1901. At that time, the field was largely static; almost every double star worker scarcely looked beyond the narrow routine of discovery, measurement with the filar micrometer, and orbit computation. Today, double star work is closely interknit with many other branches of astronomy and astrophysics, with a mutual enrichment. This fact is a guarantee of active developments in coming years.



Right: Coarse gratings like this one mounted over the objective of Sproul Observatory's 24-inch refractor are used in photographic double star work. The grating causes each star image to be flanked symmetrically by fainter images. This device reduces the errors in measurement of an unequally bright star pair.



Left: A five-second grating exposure of Castor, taken by K. A. Strand with the Sproul 24-inch refractor on December 1, 1939. This is a 75-times enlargement of the original plate. Both bright and faint components lie between secondary images formed by the grating. The position of the companion star is measured relative to the average of the primary's two images that match it in size.

Weather Prospects for the Eclipse in February

EDWARD M. BROOKS, *Allied Research Associates, Inc.*

THE SHADOW of the moon will sweep eastward all the way across the Pacific Ocean on February 4-5, 1962. Most of the path of totality will be over water, but it will cross several large islands of Indonesia and Polynesia, as shown in the accompanying maps. Australia is the only continent where partial eclipse can be widely observed.

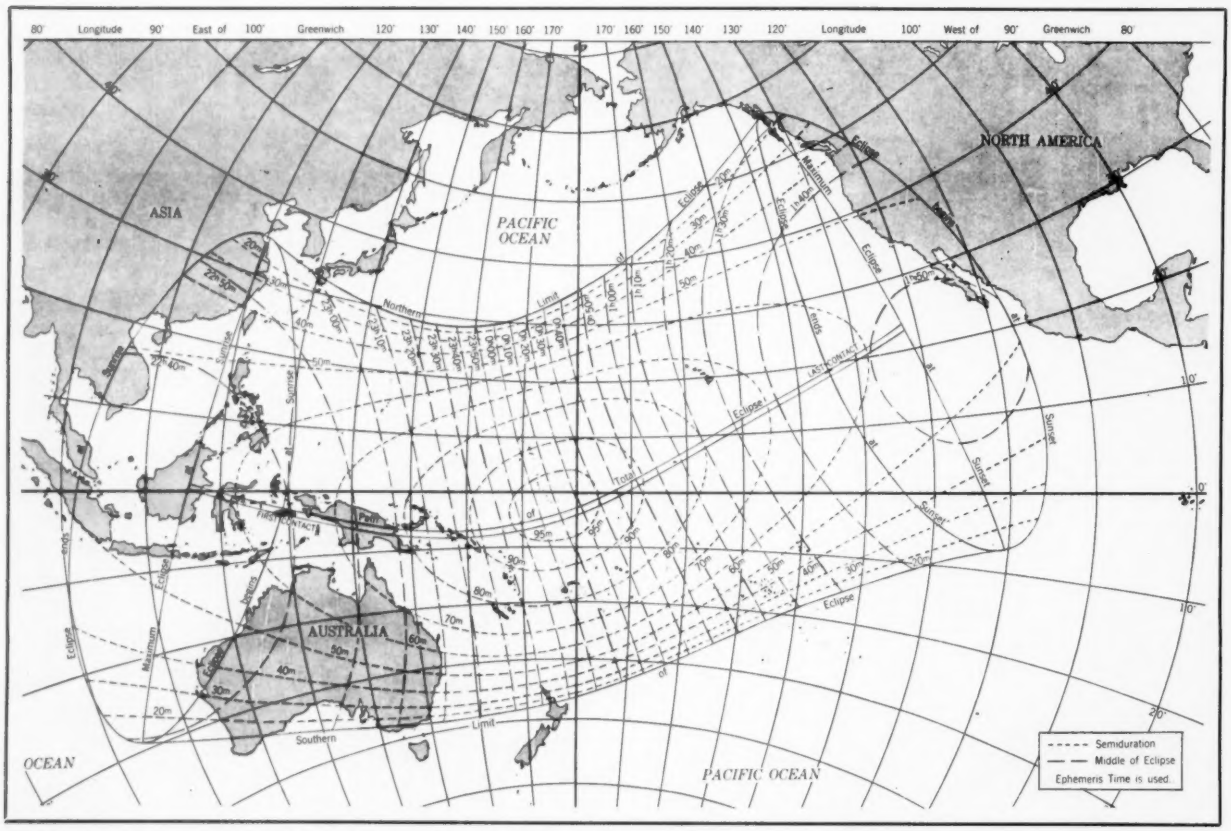
Totality will vary in duration from less than 1½ minutes at the ends of the path, where the eclipsed sun will appear on the horizon, to more than four minutes near longitude 180°. Here the sun will be only 12 degrees south of the zenith. Many of the islands within the path are mountainous, with some active volcanoes. Earthquakes are common, but it is unlikely that either volcanic activity or earth tremors will interfere with astronomical observations on any particular day.

Except in the high mountains of Celebes and New Guinea, the islands in the path of totality have typical tropical climates — a distinct annual cycle in rainfall due to the reversal of the monsoon wind. Temperatures near sea level are uniformly about 80° Fahrenheit, with high humidity, but in the mountains the climate is temperately cool. Thunderstorms and rain are relatively frequent, yet strong winds are uncommon because traveling cyclones and anticyclones are almost entirely absent from the area of the eclipse track, which lies mainly north of the equatorial low pressure belt at this time of year (Southern Hemisphere summer).

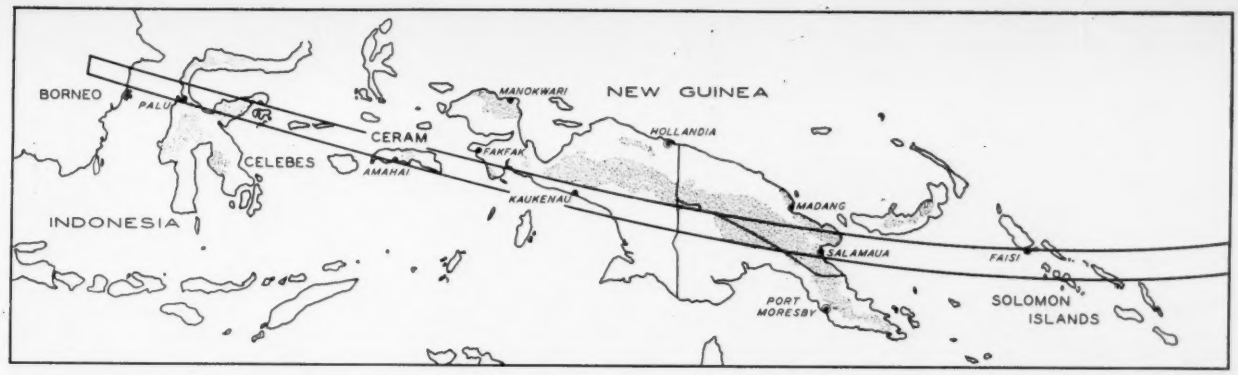
This belt is quite broad over Indonesia, shifting from day to day between 5° and 15° south latitude, spreading rain over a broad area. In addition, there are minor pressure fluctuations which travel from east to west and are called easterly waves. Rising pressure brings heavy clouds and rain, whereas falling pressure induces relatively clear conditions. The alternation of overcast and clear days resembles that of temperate latitudes. Sometimes stratiform cloud sheets cover the sky, and there is heavy rainfall for a few days.

On the north side of the equatorial doldrums, the trade winds of the Northern Hemisphere blow from nearly east at Palmyra Island and from nearly north at the Solomon Islands. Farther west, in Indonesia, the February monsoon comes from the northwest as part of a large flow of air out of the cold Asian land mass. But variations in the development of northern and southern wind systems and the boundary between them make one year's seasons different from another's. Thus predictions for any one place and future date can be no more definite in this part of the Pacific than in many other parts of the world.

However, by examining the weather records and topographical situations of many places, the writer has found seven sites that have some meteorological or astronomical advantages. Five of them are marked on the chart of Indonesia and the Solomons; the others are an "at-sea" location and Palmyra Island, about 1,100 miles south of Hawaii. My studies were made for McDonnell Aircraft Corp., which has carried out specialized observations at several recent solar eclipses.



The American Ephemeris chart of the coming total solar eclipse, which occurs on February 5th (local date) in the Eastern Hemisphere (to the left of longitude 180°) and on the 4th in the Western Hemisphere. In Hawaii, partial eclipse of the sun will last well over two hours, but the ending of eclipse charted along the west coast of North America will be nearly unobservable. Palmyra Island is indicated at longitude 162° west, latitude 6° north.



The path of totality is 62 miles wide at Amahai, Ceram, increases to 77 as it crosses New Guinea, and reaches a maximum of 91 miles east of the Solomons. At Palmyra Island, not included in this chart, the path is 82 miles wide.

A. **Palu, Celebes** (119°.9 E., 0°.9 S.). Located at the head of Palu Bay and sheltered by high mountains, Palu has the smallest known average rainfall (21 inches) of any land area within the eclipse track. Unfortunately, local mountain and land breezes at night meet the northwest monsoon in February and cause cloudiness with light rain that lingers on after sunrise. Furthermore, the eclipsed sun will be only four degrees high, barely clearing a mountainous horizon, and totality will be short.

B. **Amahai, Ceram** (128°.9 E., 3°.3 S.). A dry season is experienced in February because Amahai and nearby places are on the south coast of Ceram. The rather strong summer monsoon brings winds from the northwest, but Amahai is in the "wind shadow" of a mountain range that reaches almost 1,500 feet above sea level. Normal February rainfall is only four inches, compared with 17 on the north coast of Ceram. Amahai also experiences a land breeze at eclipse time. Its climate resembles that of Amboina, 60 miles to the southwest and outside totality, where weather records have long been kept.

Amboina has minimum hourly rainfall between 7 and 8 o'clock in the morning, and eclipse time at Amahai is 7:10. In February, Amboina has an average of 14 rainy days, including six with thunderstorms. However, during the month the sun shines two thirds of the time it is above the horizon, and there is more sunshine in the morning than in the afternoon. The eclipsed sun at Amahai will be 15 degrees high and totality will last nearly two minutes.

C. **Kaukenau, Netherlands New Guinea** (136°.4 E., 4°.7 S.). Here we have the advantages of a commercial airport, a long stretch of coastline lying well within the shadow path, the protection of the 15,000-foot Nassau range to the north, the sun about 23 degrees high, and totality lasting over two minutes on the central line.

Because of the weakness of the prevailing circulation, sea and valley breezes combine into a well-pronounced onshore and upslope flow during the daytime, giving convective thunderstorms and squalls in the afternoon and evening during February. It rains almost every day on Mount Carstensz, even though this is the "dry season." However, a combined mountain and land breeze makes mornings much drier, as shown by a four-per-cent probability of rain in the morning on Waarnemings Island (off the coast near the west end of the mountain range) between January 1 and February 15, 1910. Thus, meteorological conditions are usually favorable at the local time of eclipse, 7:45 a.m.

D. **Salamaua, northeast New Guinea** (147°.1 E., 7°.0 S.). On the eastern coast of New Guinea, Salamaua is just south of the head of Huon Gulf. It is sheltered from the northwest monsoon by peaks ranging from 2,000 to 10,000 feet, so there are definite land and sea breezes. The land breeze is from the south and normally dies out between 9 and 10 o'clock in the morning, just after mid-eclipse time, which is about 8:40. Low-level cloudiness is generally scarce, the sky coverage being 3/10 or less in 82 per cent of the 9 a.m. observations, according to British Meteorological Office data published by Commission 13 of the International Astronomical Union.

Between 10 a.m. and 5 p.m., large cumulus cloud development occurs, and severe thunderstorms are frequent in the evening. Sudden cloud coverage changes occur at Salamaua, a distinctly local feature. February rainfall is about 6.3 inches, occurring on 14 days on the average. It is 7.5 inches at Lae, located at the head of Huon Gulf.

On the coast north of Huon Gulf is another region sheltered from the monsoon by mountains and well within the path of totality. There Finschhafen has only three inches of February rainfall, but appears to be cloudier than Salamaua in the morning. The differences in rainfall are mainly in the afternoon and evening, irrelevant to the eclipse. Astronomically, the Huon Gulf area is favored with a solar altitude of 37 degrees and a centerline duration of nearly $2\frac{3}{4}$ minutes. In reaching the ground observer, the sun's light will pass through 70-per-cent more air than if the sun were in the zenith.

E. **Faisi Island, Solomons** (155°.9 E., 7°.1 S.). This small island is in the harbor on the east side of Shortland Island, south of 7,000-foot Mount Taroka on Bougainville. Downslope motion of the prevailing north wind in February gives an average cloudiness at Faisi of 50 per cent, whereas this figure is 55 to 70 per cent elsewhere in the Solomons. Faisi has its minimum rainfall in March, while the other islands are experiencing the season's maximum. On the other hand, Faisi has more days with some rain than elsewhere in this area.

The sun's altitude will be 50 degrees, but this site is close to the northern edge of the shadow track.

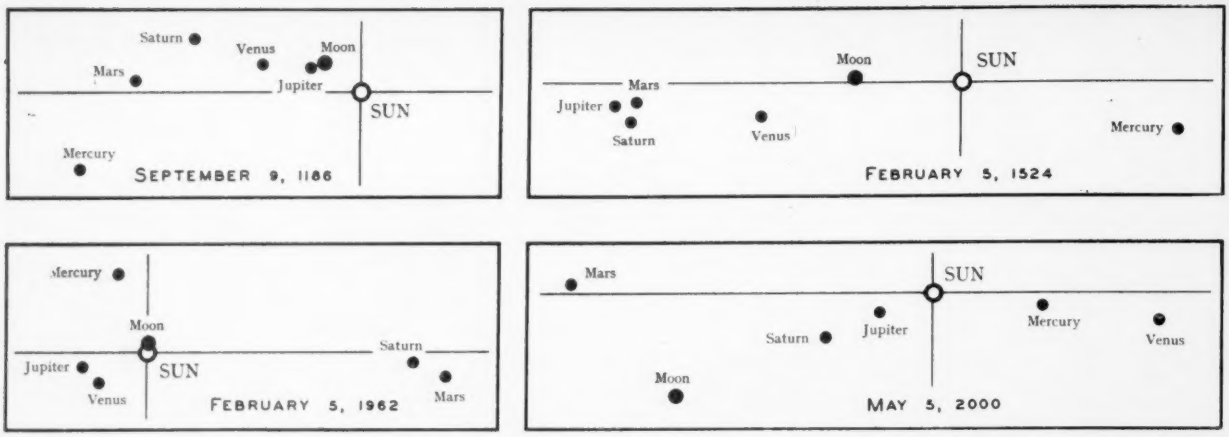
F. **Pacific Ocean** at 175°.5 W., 1°.4 S. Located between Baker and Canton islands, this is the approximate intersection of the central line with the equatorial belt of deficient rainfall caused by relatively low water temperature. Baker Island is extremely dry, with only two thirds of an inch of rainfall during February. Average cloudiness is roughly 1/10 or a little less, with moisture in the air column relatively shallow.

Although the sun will be 72° high and totality will last a full four minutes, the observations must be made from sea or air, there being no land within the shadow's path between the Solomons and Palmyra Island.

G. **Palmyra Island** (162°.1 W., 5°.9 N.). With totality lasting more than three minutes and the sun 50 degrees above the horizon, this large island has many points in its favor for American expeditions, as Honolulu is only four hours away by air. February cloudiness averages about 5/10 or a little more, but showers and wind squalls are frequent. Of February observations, 16 per cent reported squalls, mostly from the east, occurring at any time, day or night. Torrential rains and strong winds that may last two or three consecutive days are caused by the convergence of the northeast and southeast trade winds, for Palmyra lies within the intertropical convergence zone most of the year.

From records of the U. S. Navy, which occupied Palmyra during World War II, 26 inches of rain fell on 24 days in February, 1942, and eight inches on 25 days that month in 1943. An observer stationed

(Continued on page 321)



In these charts of four important compact groupings of the sun, moon, and naked-eye planets, the author has taken the latitudes of these bodies into consideration, to give a truer picture of their relative locations. During the 1962 event the moon will eclipse the sun. In each case, the horizontal line through the sun's position is the ecliptic, while the vertical line indicates solar longitude. The scale of the charts is about 7½ degrees per inch.

Compact Planetary Groupings

JEAN MEEUS, *Kesselberg Observatory, Belgium*

ON FEBRUARY 5, 1962, as seen from the earth, the five naked-eye planets Mercury, Venus, Mars, Jupiter, and Saturn will be in the sun's vicinity. In addition, there will be a new moon, so all seven "planets" of the ancients will appear together in the sky. The distance between the most widely separated planets, Mars and Jupiter, will be only 16 degrees. On this occasion, the sun becomes totally eclipsed, affording observers within the path of totality a view of this very rare planetary configuration.

In the history of science, we find records of two similar groupings some centuries ago, in September 1186 and in February 1524, but there have been others.

I have computed all instances that have taken place during the years from A. D. 1000 to 2400. The calculations were made with the excellent tables of P. V. Neugebauer, *Tafeln für Sonne, Planeten und Mond*, published at Leipzig, Germany, in 1914. Taking 30 degrees of longitude as the maximum extent of a compact grouping, including the sun and moon, I found the 14 occurrences listed below.

The first column gives the date for which the computation was made, the Julian calendar being used before 1582, the Gregorian after. The second column is the geocentric longitude of the sun, referred to the mean equinox of date. The next six columns indicate for the moon and planets the differences between their geocentric longitudes and the sun's. A positive difference means that the planet is east of the sun, while negative shows that it is west.

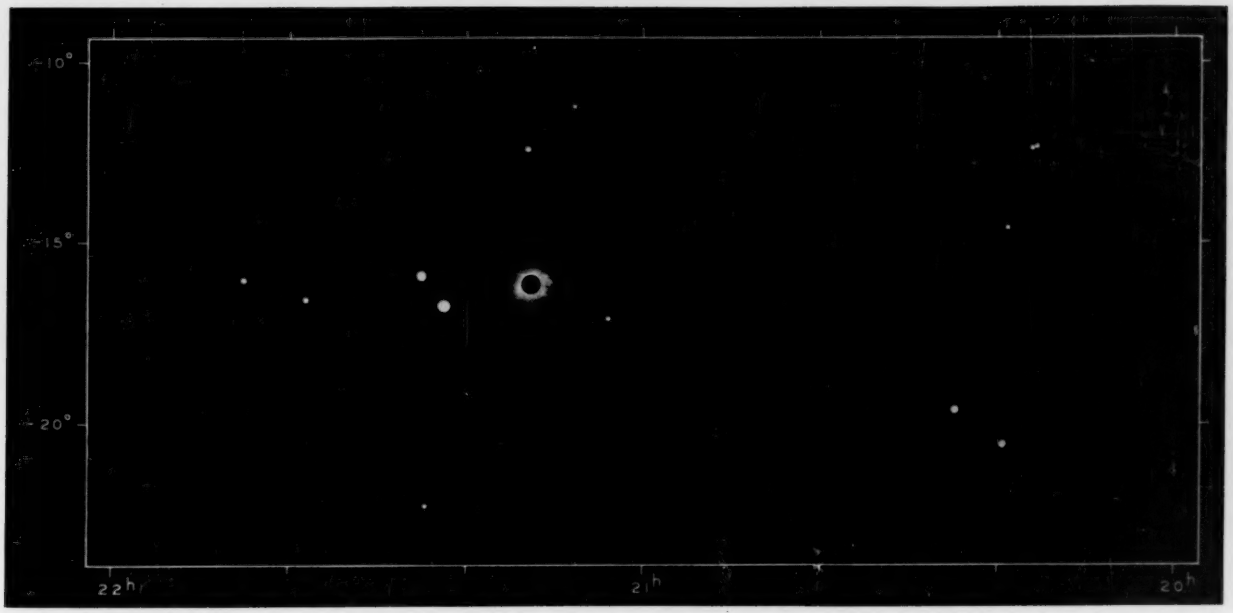
Next is a column for the constellation where most of the objects are situated on the date concerned, using modern constellation boundaries. The least separation of the two extreme planets is also given, not necessarily for the same date as in the first column. Finally I have shown whether or not a solar eclipse occurs at the new moon nearest the time of the grouping.

Generally the event lasts for at least two days, this being the interval required for the moon to travel 30 degrees. However, it is theoretically possible for the situation to persist up to five days. With 30 degrees as an upper limit for the overall separation, the 1962 grouping will last 71 hours, from 5^h Universal time on February 3rd to 4^h on the 6th.

Inspection of the table shows no simple periodicity in these close approaches of planets. There are four cases of a repe-

GROUPINGS OF FIVE PLANETS, SUN, AND MOON, A. D. 1000 TO 2400

Date	SUN	Moon	Mercury	Venus	Mars	Jupiter	Saturn	*Const.*	*Sep.*	*Eclipse*
	°	°	°	°	°	°	°		°	
1007 Aug. 15.0	146.4	− 7.4	+ 8.0	+ 1.1	−12.8	+ 0.4	+ 7.3	Leo	21	No
1186 Sept. 15.0	178.4	+ 1.8	+12.4	+ 4.4	+10.0	+ 2.3	+ 7.3	Vir	12	Partial
1284 Dec. 10.0	266.2	+15.1	+ 9.1	+26.7	+ 8.7	+10.2	+29.0	Sgr	28	Annular
1285 Jan. 6.5	294.2	−10.3	+15.5	−13.9	+ 2.2	−11.4	+ 4.1	Cap	29	No
1483 Oct. 30.0	225.3	−19.3	+ 5.5	−17.8	−22.0	−20.4	− 4.8	Lib	27	No
1524 Feb. 5.0	325.1	+ 4.8	− 9.7	+ 8.9	+14.4	+15.2	+14.6	Aqr	24	Annular
1624 Sept. 11.0	168.6	−20.4	+ 4.0	− 3.1	− 8.0	− 5.7	−22.9	Leo	27	Partial
1662 Dec. 10.0	258.3	− 8.1	− 6.6	−15.2	+ 6.3	−18.5	− 9.5	Oph	25	No
1821 April 2.5	12.4	− 1.8	−13.6	−13.3	−17.7	− 4.6	+ 3.5	Psc	21	No
1821 April 30.5	39.8	−20.8	−25.7	− 6.0	−23.4	−25.3	−20.5	Psc	26	No
1962 Feb. 5.0	315.7	− 0.1	+ 1.2	+ 2.1	−13.3	+ 2.9	−11.9	Cap	16	Total
2000 May 5.0	44.8	+11.3	− 4.9	−10.0	+16.0	+ 2.3	+ 4.8	Ari	26	No
2040 Sept. 8.0	166.0	+15.7	+20.5	+26.9	+29.8	+24.2	+25.4	Vir	29	No
2100 Nov. 2.0	219.7	− 1.9	−15.6	−28.7	− 7.1	− 4.7	− 9.0	Vir	29	No



For viewers in the path of the coming February eclipse, totality will be a striking spectacle, the sun's corona and the two brightest planets, Venus and Jupiter, being close together in the sky. Mercury will be inconspicuous a few degrees north (above) the sun, while Saturn and Mars are quite a distance to the west (lower right). Nu Aquarii (near Mercury) is plotted, and the following stars in Capricornus: Alpha (double), Beta, Gamma, Delta, Zeta, and Theta.

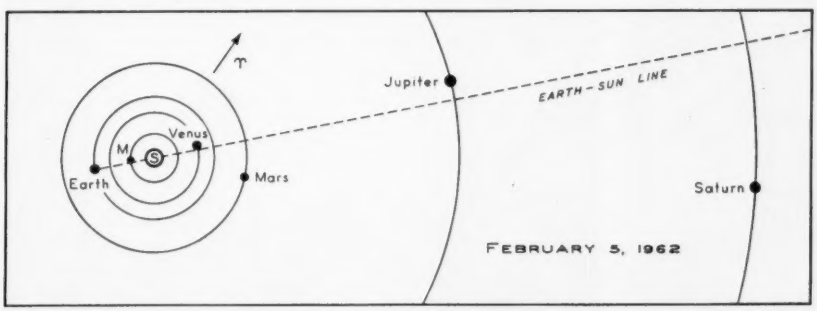
tition after a lapse of about 40 years (1483-1524, 1624-1662, 1962-2000-2040), and two cases close to 100-year intervals (1186-1284, 1524-1624). The events of December 10, 1284, and January 6, 1285, occurred on successive new moons; a similar pair took place in 1821 on April 2nd and 30th. Although the next few compact groupings will occur at short intervals until 2100, after that there will be no others for more than three centuries.

Only two groupings have separations of less than 20 degrees, that of 1186 with 12 degrees, and 1962 with 16. In five of the 14 cases, all planets are situated on the same side of the sun. In 1186 and 1284 they were to the east, and this will happen again in 2040. At the second 1821 and the 2100 events, the six bodies lie west of the sun.

In February, 1524, the seven "planets" were in the astrological "humid" signs of Aquarius and Pisces. The coming celestial event must have terrified astrologers of that time. A general flood was predicted, but in many places February was the driest month of the year!

Because they include the sun, these compact groupings are generally not observable. Of all 14 events in the table, only one occurs at a total solar eclipse, when for observers within the moon's umbral shadow the sky around the sun will be dark enough for planets to be seen. This remarkable event happens next February 5th, when the five planets Mercury to Saturn will all be visible within 14 degrees of the eclipsed sun.

A number of planetary configurations combine to make this possible. On eclipse date Mercury will be at inferior conjunction, in the near part of its orbit, and Venus will be about a week past superior conjunction. Although Mars' passage by the sun occurs on December 14th, this planet will still be only 13 degrees to the west on February 5th. Slow-moving Jupiter and Saturn will be passed by the sun on February 8th and January 22nd, respectively.



The heliocentric positions of the planets on February 5, 1962, show how the line from Earth to Sun (S) passes close to Mercury (M), Venus, and Jupiter, with Mars and Saturn not far from it. The arrow indicates the direction of the March equinox point on the sky.

1961 SOLAR ECLIPSE REPORTS

The May, June, and July-August numbers of *l'Astronomie*, journal of the Société Astronomique de France, contain 72 pages of reports on the total solar eclipse of February 15, 1961. The track of totality passed across France and Italy, and fine weather prevailed for thousands of amateurs in those countries. The eclipse experiences of both individuals and observing groups are recounted in French, accompanied by about 50 pictures of the total and partial phases. The society's address is 28 Rue Serpente, Paris 6, France.

WEATHER PROSPECTS FOR THE ECLIPSE IN FEBRUARY

(Continued from page 319)

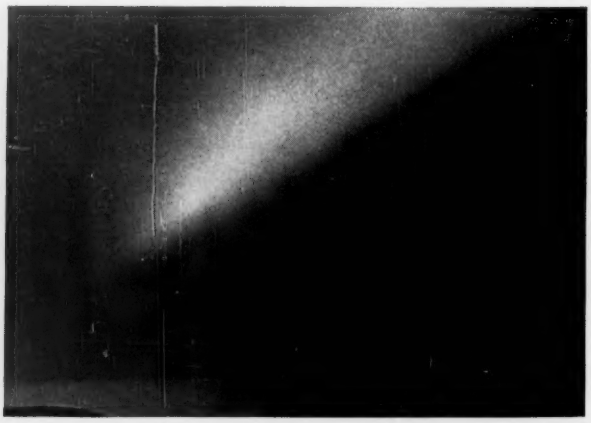
there for a year beginning November 1, 1920, without weather instruments, recorded clear weather on less than 40 days, showers on 105, and rain on the remainder.

ED. NOTE: Palmyra Island is presently being developed into a resort by a long-term lessee. Occupied until early this year by the U. S. Air Force, the island has a 6,000-foot airstrip and a deep-water boat anchorage, with living quarters and a dining hall. There is no scheduled transportation from Honolulu, but the development company will organize a charter flight for eclipse observers. Prompt inquiries should be made to Polynesian Paradise, Inc., 5800 Avion Dr., P. O. Box 90367, Los Angeles 9, Calif.

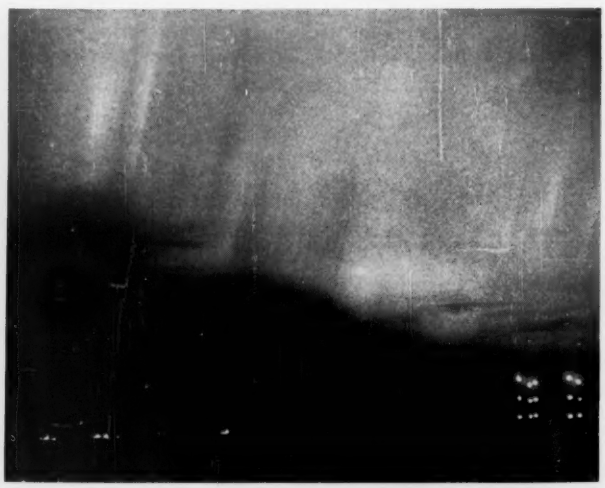
This company's director of research, J. D. Mockett, quotes the island's owners: "Weather on Palmyra during January and February is usually excellent. These two months are considered to be the best during the year from the weather standpoint, but occasional cloudy days can be expected, and should approximate those in Hawaii during the same period."

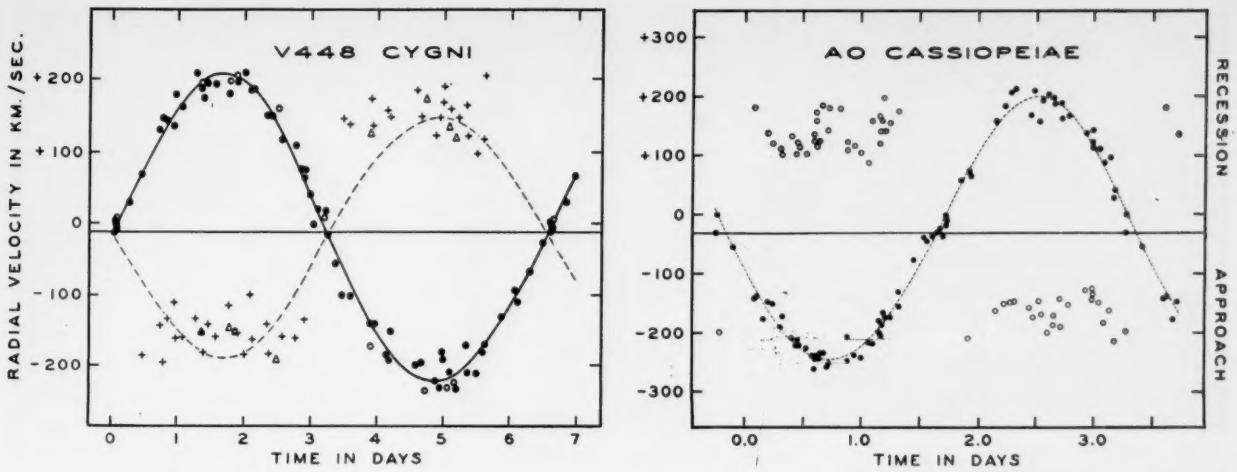
Philip J. Del Vecchio's photograph (left) of the September 30th aurora shows a corona which was located just south of his zenith at Paterson, New Jersey, about 8:30 p.m. Eastern standard time. The rayed band (above), prominent in the northwestern sky over Providence, Rhode Island, was recorded by Frank J. Sulloway, II, at 9:40 p.m. EST in a 30-second exposure. The display was the most spectacular in years.

PICTURES OF THE SEPTEMBER 30th AURORA



Near Lincoln, Nebraska, Peter Schultz obtained these four photographs. The two above show the southeastern sky about 10 minutes before auroral maximum, which occurred around 9:00 p.m. Central standard time; Deneb Kaitos is above the car in both pictures. Below left is the western sky as it appeared at approximately the same time, Arcturus being seen at right center. The last picture depicts the northeastern sky and includes a bank of clouds that obscure part of the aurora. All four were taken at f/3.5 on 35-mm. Agfa Isopan Record film, with exposures ranging from 15 to 25 seconds. Through a yellow filter, the aurora seemed especially well defined and bright. Other accounts of this display are in the November issue, page 271.





These radial-velocity curves for two massive binary star systems show abnormal features. In each case, symbols along the heavy curve represent measured speeds of approach or recession of the brighter component, other symbols those of the fainter. V448 Cygni (left) is an 8th-magnitude eclipsing variable, whose orbital period is 6.52 days. Its diagram is by R. M. Petrie, from his work with the 73-inch reflector of the Dominion Astrophysical Observatory. At the right is K. D. Abhyankar's plot of AO Cassiopeiae, a 6th-magnitude eclipsing system. For each binary the observed velocities of the secondary star seem to cluster around two discrete values, instead of following a smooth curve like that of the primary star.

Some Massive Binary Stars

OTTO STRUVE, *National Radio Astronomy Observatory**

THIS PAST SUMMER the Argentine astronomer Jorge Sahade, of La Plata Observatory, asked me to read an article he had prepared for publication. He seemed surprised that I did not begin it immediately, but probably he did not know that the problem of large stellar masses, with which his paper deals, embarrasses me.

The reason for this dates back to the 1920's, when I published a spectroscopic orbit of the *B*-type star 27 Canis Majoris. From the observations at Yerkes Observatory between 1907 and 1928, I inferred that the radial velocity varied with a period of 3.2 years, having a range of more than 200 kilometers per second. It was then customary to interpret all variations in stellar radial velocities as due to orbital motion. Hence I derived for 27 Canis Majoris a supposed mass considerably in excess of 1,000 times the sun's.

My results were almost immediately criticized by B. P. Gerasimovich, who concluded that the period was close to one day, making the mass of 27 Canis Majoris much smaller. He argued that the Yerkes observations of this southern star were all made when it was close to the meridian, and therefore were at intervals of one sidereal day. Thus the star could seem to have a much longer period, for the same reason that a rapidly rotating wheel viewed by intermittent glimpses can appear to be turning very slowly. But I made new observations when the star was several hours from the meridian, and showed that a period of about one day could not explain the observed variation in radial velocity.

Even in 1928, a stellar mass 1,000 times the sun's was inconsistent with what was known from other spectroscopic binaries. Fortunately, my erroneous interpretation of the radial-velocity measurements did not mislead A. S. Eddington and H. N. Russell in their investigations of the internal constitution of the stars. Both of these astronomers had uncanny intuition in disregarding illogical interpretations of observations. Eddington, in particular, had concluded that stars over 100 times as massive as the sun would be disrupted by radiation pressure in their interiors.

The observations of 27 Canis Majoris were quite reliable, but it later turned out that the radial-velocity curve does not repeat itself. The star was not a binary at all! The variation I had observed is probably similar to that found by D. B. McLaughlin in several other emission-line *B* stars; its cause is still somewhat uncertain.

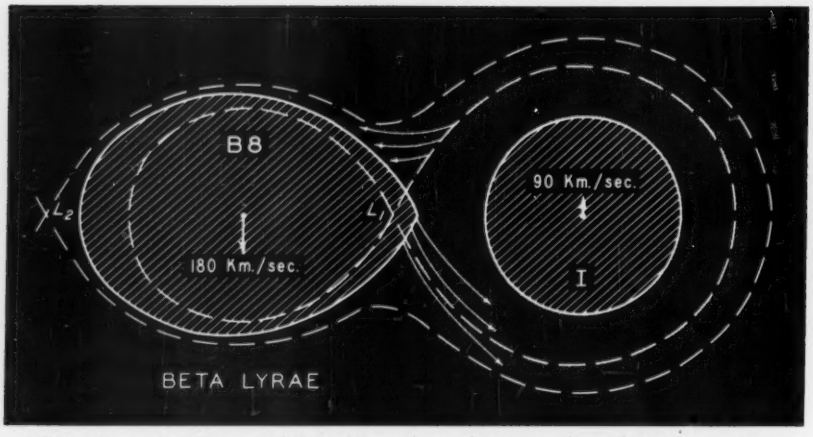
Recently, the problem of large stellar masses has assumed new importance. P. Ledoux in 1941 pointed out that very massive stars would be unstable due to radial pulsations. In 1958, A. D. Code and T. E. Houck found that the *B*1 supergiant star Zeta[1] Scorpii, a member of the galactic cluster NGC 6231, has a bolometric absolute magnitude of −11.8. Because this supergiant is not known to be a binary, its mass cannot be determined directly. But, from its very high luminosity Code and Houck suggested that the mass might be in excess of 94 suns.

The latest theoretical investigation of the pulsational instability of very massive stars was carried out in 1958 by M. Schwarzschild and R. Härm. Using the best available models of stellar structure, they deduced that stars having masses greater than 60 suns must be unstable. The Princeton astronomers pointed out the possibility that a new-formed star with a mass between 60 and 65 suns "could go through its original Kelvin contraction unharmed but would start pulsations the moment the nuclear processes take over as the main energy source, and these pulsations would build up in amplitude in less than half a million years to such a strength as to disrupt the star."

According to these authors, "This pulsational instability arises from the following physical circumstances. A possible energizing mechanism for pulsations rests in the nuclear-energy sources in the central region of a star. The main damping mechanism for pulsations, caused by heat leakage, occurs predominantly in the envelope. For stars with normal masses . . . the pulsation amplitudes are found to be very small in the central region as compared with those in the envelope. Accordingly, the energizing processes in the core are ineffective compared with the damping processes in the envelope, and the stars are pulsationally stable.

"For extremely massive stars, however, [because of radiation pressure] . . . the pulsation takes on more and more the character of a slow alternation of homologous expansions and contractions, in which the relative pulsation amplitudes in the core are quite comparable with those in the envelope. Here, then, exists

*Operated by the Associated Universities, Inc., under contract with the National Science Foundation.



This schematic diagram of Beta Lyrae is an interpretation of recent spectroscopic observations. The component stars are represented by hatching, with dots around the smaller one indicating gas that has escaped from the unstable, larger, but less massive B8 component. Further details are discussed in the text. After a chart prepared by Mrs. Mary-Jane Wade at the National Radio Astronomy Observatory, under the author's direction.

the possibility for the energizing processes in the core to overcome the damping processes in the envelope, i.e., for pulsational instability to develop. Indeed, Ledoux showed that pulsational instability is to be expected for all stars in which radiation pressure exceeds a certain value, i.e., for all stars with masses above a critical mass."

But Zeta[1] Scorpii and Plaskett's star (the spectroscopic binary HD 47129) have been reported as possessing masses of the order of 90 suns. If they really do, they must be pulsationally unstable and approaching disruption. Schwarzschild and Härm ask observers to verify whether such stars have spectra of the P Cygni type. This would imply ejection of matter, hence instability.

For a second test, they ask whether accurate photoelectric measurements of very massive stars show any indications of regular light variations with periods of the order of one-third to one day, such as would be caused by radial pulsations. The answer for the first test is probably yes; for the second test we have no information yet.

Sahade's paper, which I mentioned earlier, discusses several other stars reported to exceed 60 or 65 solar masses. The most famous case is Beta Lyrae, a binary for which a team of Yerkes astronomers in 1941 found masses of 78 suns for the *B*8 primary star and 52 for the secondary. More recent work has shown unmistakably that these early results were incorrect, and that the secondary component (the star that is in front of the *B*8 component at primary eclipse) is actually the more massive of the two. This conclusion could not have been anticipated in 1941, when astronomers were firmly committed to the classical mass-luminosity relation. At that time it seemed obvious that the secondary star, being fainter, was also less massive.

But now we know that the mass-luminosity relation applies only to main-sequence stars, and need not hold for those that are still contracting or that have evolved away from the main sequence. The best available masses in the case of Beta Lyrae are about 10 suns for the *B*8 star and 20 for the companion. Hence Beta Lyrae does not violate the limit that was set by Schwarzschild and Härm.

Shown above is a model of Beta Lyrae, based upon the observations by Dr. Sahade and me at Mount Wilson in 1958. The larger, *B*8 star has only half the mass of the smaller companion, labeled **I**. Arrows for each star are marked with the orbital velocity. The inner figure-eight dashed line, passing through the Lagrangian $\mathbf{L}_1$ point, marks a stability limit for the two components. Because the *B*8 star extends outside this curve, it is unstable, and will shed material.

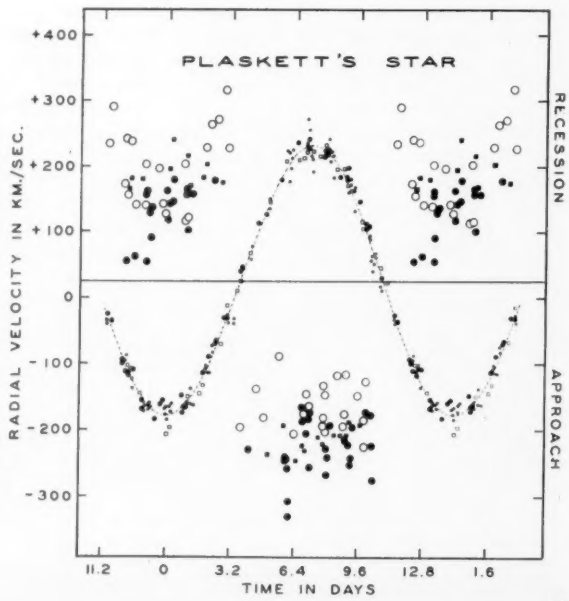
This leakage, in the direction of the long curved arrows, probably accounts for the very prominent gas stream revealed by spectroscopic observations immediately after principal eclipse. This gas forms an extensive cloud, shown by stippling in the diagram. The outer dashed curve, passing through the Lagrangian point $\mathbf{L}_2$, represents a limit of stability for the system as a whole; gas ejected beyond it could escape into space.

The case of Plaskett's binary is more complicated. In quoting masses of the order of 90 suns for each of its components, the Princeton astronomers cite my greatly simplified discussion in SKY AND TELESCOPE for November, 1957, page 18, based on only approximate orbital data. A more thorough investigation of this remarkable star has since been published by K. Abhyankar in the *Astrophysical Journal Supplement Series* in 1959.

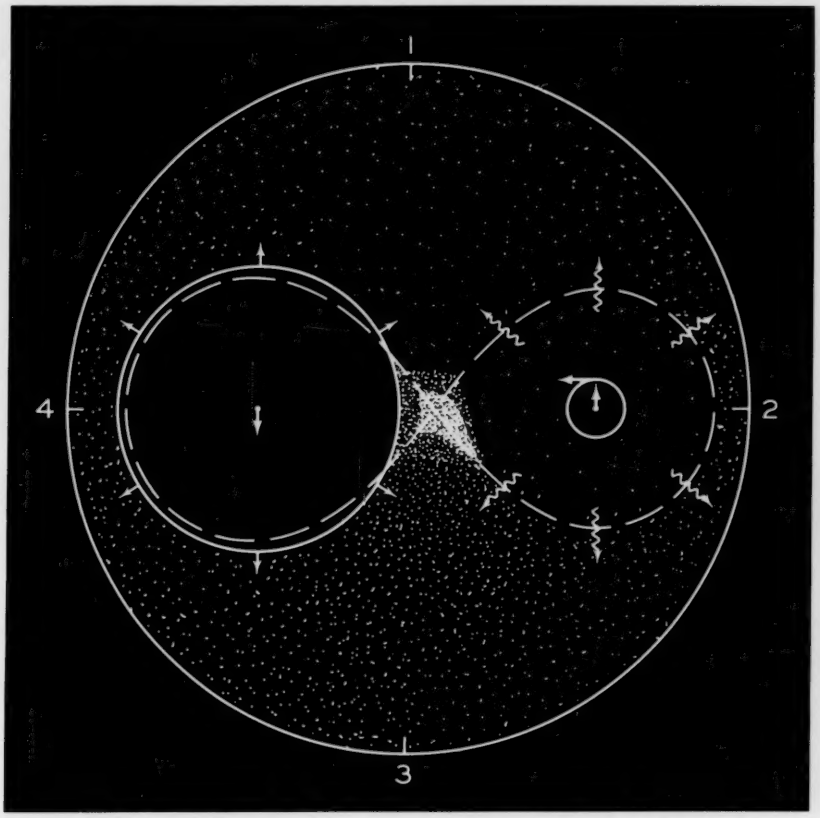
The principal complication is that the radial-velocity curves of the two components give drastically different values for the velocity of the system's center of mass. For a normal double star, it is obvious that these values must be identical, but here they differ by something like 100 kilometers per second. This cannot be explained by errors of measurement or by any purely gravitational effect.

Abhyankar's study indicates that the velocity curve of the primary component remained the same during the interval covered by J. S. Plaskett's observations (1922), those at McDonald Observatory (1947-48), and at Lick and Mount Wilson (1956-57). But the measured radial velocities of the secondary were systematically different in the three series.

Sahade has pointed out that my McDonald spectrograms showed strong lines of the secondary component in the blue and violet sections of the spectrum, while on Lick and Mount Wilson spectrograms of nine years later the secondary's lines



In this diagram, Abhyankar has collected all radial-velocity observations of Plaskett's star, a massive spectroscopic binary in Monoceros. Small symbols along the curve are measured velocities of the brighter component, large symbols of the fainter. Observations were made in 1922, 1947-48, and 1956-57. Note that the large open circles, representing the latest measures, are displaced upward. The author explains this by the presence of gas streams. From the "Astrophysical Journal Supplement Series."



Jorge Sahade devised this model of Plaskett's massive binary to explain the peculiarities of the system. The smaller star, of spectral type O8, is hotter and brighter than the large, cool secondary. The latter extends outside the stability limit indicated by the dashed curve, hence is unstable and ejects matter. Stippling denotes escaped gas. The period of this binary is 14.4 days, and in the course of an orbital revolution we view the system from the directions 1, 2, 3, and 4 in succession. Adapted from a La Plata Observatory diagram.

could be clearly seen only in the visual region. Finally, it has become apparent from both my work and Abhyankar's that the radial velocities of the secondary do not follow a rhythmic curve, such as would be expected if the Doppler displacements were caused only by orbital motions. Instead, as shown in the plot opposite, they indicate a roughly constant value (though with a large scatter) of some +150 kilometers per second when the radial velocity of the primary is nearly −200 (revolving toward us). It is about −250 when the primary is moving from us at some +225 kilometers per second.

Therefore, Sahade suggested that the absorption lines of the secondary are strongly affected by a radial outflow of gas from it, this star filling its lobe of the critical equipotential curve, as illustrated above. A somewhat similar situation was found for the spectroscopic binary V448 Cygni by the Canadian astronomer R. M. Petrie. According to Sahade, the observations of Plaskett's star indicate about 40 solar masses for the primary and 60 for the secondary.

Still another case in the recent literature is that of the binary HD 698, J. A. Pearce having found 113 solar masses for the brighter member and 45 for the fainter. However, McDonald spectrograms taken by M. Rudkjöbing and me do not show any lines of the secondary component, and I feel reasonably certain that the large mass assigned by Pearce to the primary was ill-founded. Sahade is planning to observe this star again at higher dispersion to test the earlier results.

With regard to Zeta[1] Scorpii and other extremely luminous early *B* supergiants, Sahade suggests that these stars have evolved away from the main sequence, and therefore are more luminous. Hence, even these remarkable stars are probably not violating the limit of Schwarzschild and Härm.

These two astronomers do not mention the so-called Trumpler stars, nor does Sahade. But G. P. Kuiper included them in his discussion of the mass-luminosity relation, and C. W. Allen placed them in his 1955 book, *Astrophysical Quantities*. Masses of the order of 1,000 suns have been attributed to these objects, from measurements of the radial velocities of *O*-type stars in open clusters that indicate red shifts with respect to the clusters themselves. R. J. Trumpler interpreted this phenomenon as Einstein's gravitational red shift. My own observations led me to discard this interpretation, but I believe that up to his death Trumpler never quite accepted my reasoning. The Trumpler effect — the red shift itself — is certainly real. If not due to gravitation, it remains unexplained. It should be investigated more thoroughly.

In summary, it would seem that there is no reliable observational evidence for stellar masses greater than about 65 suns. Sahade stresses the important point that all very massive spectroscopic binaries show spectral indications of gas streams, ejection of matter, and exchange of mass between the two components. All these phenomena suggest that we are dealing with unstable stars, whose evolutionary tracks in the Hertzsprung-Russell diagram may depart from those of single stars.

QUESTIONS... FROM THE S+T MAILBAG

Q. What is meant by the celestial longitude and latitude of a planet?

A. Celestial (geocentric) longitude and latitude are sky co-ordinates sometimes used instead of right ascension and declination, particularly to indicate the positions of the sun, moon, and planets. Celestial latitude is expressed in degrees north (+) or south (−) of the ecliptic, the sun's annual path around the sky. Longitude runs eastward along the ecliptic from the March equinox, where the ecliptic and celestial equator cross, and is counted from 0° to 360°. This system is known as *ecliptic co-ordinates*.

Q. What is the most remote celestial object visible to the naked eye?

A. This distinction has been claimed for both Messier 31, the great Andromeda galaxy, and the Triangulum galaxy, Messier 33. Their distances differ by less than the uncertainties of measurement, and are roughly two million light-years.

Q. In the double star list on page 262 of the November issue, what is meant by the Greek letters in such star designations as Σ3062, OΣ18, β1053?

A. They indicate the discoverer of the pair in question; Σ stands for Wilhelm Struve, OΣ for Otto Struve, and β for S. W. Burnham.

Q. How small a crater can be seen on the moon with a 6-inch telescope?

A. One that is 1½ miles across, if the telescope optics are perfect and seeing excellent, according to E. A. Whitaker.

Q. What is the brightest nova on record?

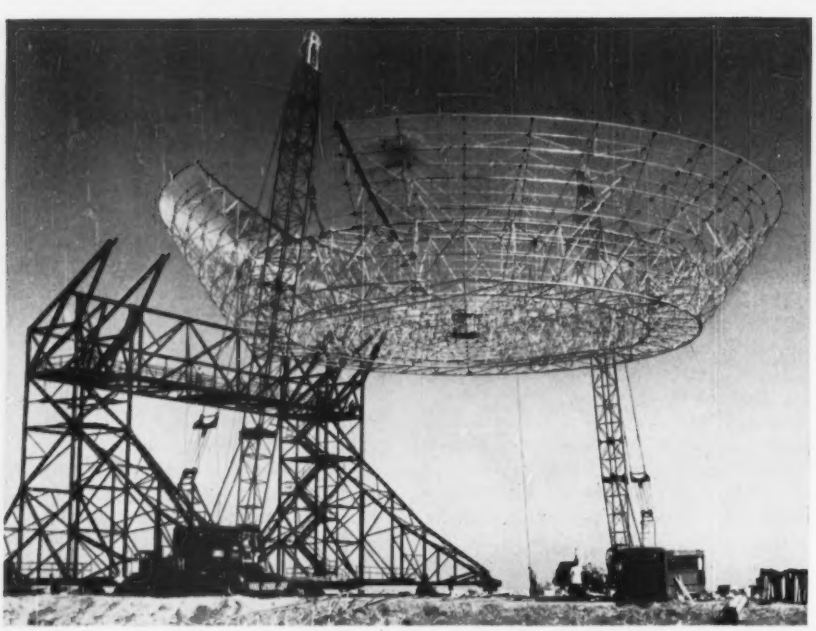
A. Nova Aquilae of 1918, which attained magnitude −1.1, only slightly fainter than Sirius.

Q. How can I get started in variable star observing?

A. The American Association of Variable Star Observers supplies the necessary information to new members. Write AAVSO, 4 Brattle St., Cambridge 38, Mass.

The 150-foot paraboloidal radio reflector of Stanford University. Below, it is being hoisted onto its altazimuth mounting. Three long white tubes, lying on the ground at the right in the aerial view above, will form the tripod support for the antenna feed at the focus. Surrounding two of the tubes are the concrete piers on which the reflector was built.

TWO GIANT RADIO TELESCOPES



QUITE DIFFERENT instruments for radio astronomy research are now under construction in the Western Hemisphere. The 150-foot lightweight aluminum reflector of Stanford University contrasts sharply with the massive concrete-and-steel fixed bowl, nearly a fifth of a mile in diameter, that is being built in Puerto Rico for the Department of Defense.

A long-standing ban on the erection of visible structures in the foothills on the Stanford campus at Palo Alto, California, was relaxed for the 160-foot-high instrument. Costing $350,000, it is presently the largest steerable paraboloidal reflector in the United States. It is the first of three such receivers being designed and constructed by Stanford Research Institute. The others are for the Air Force in Massachusetts and the Navy in Virginia.

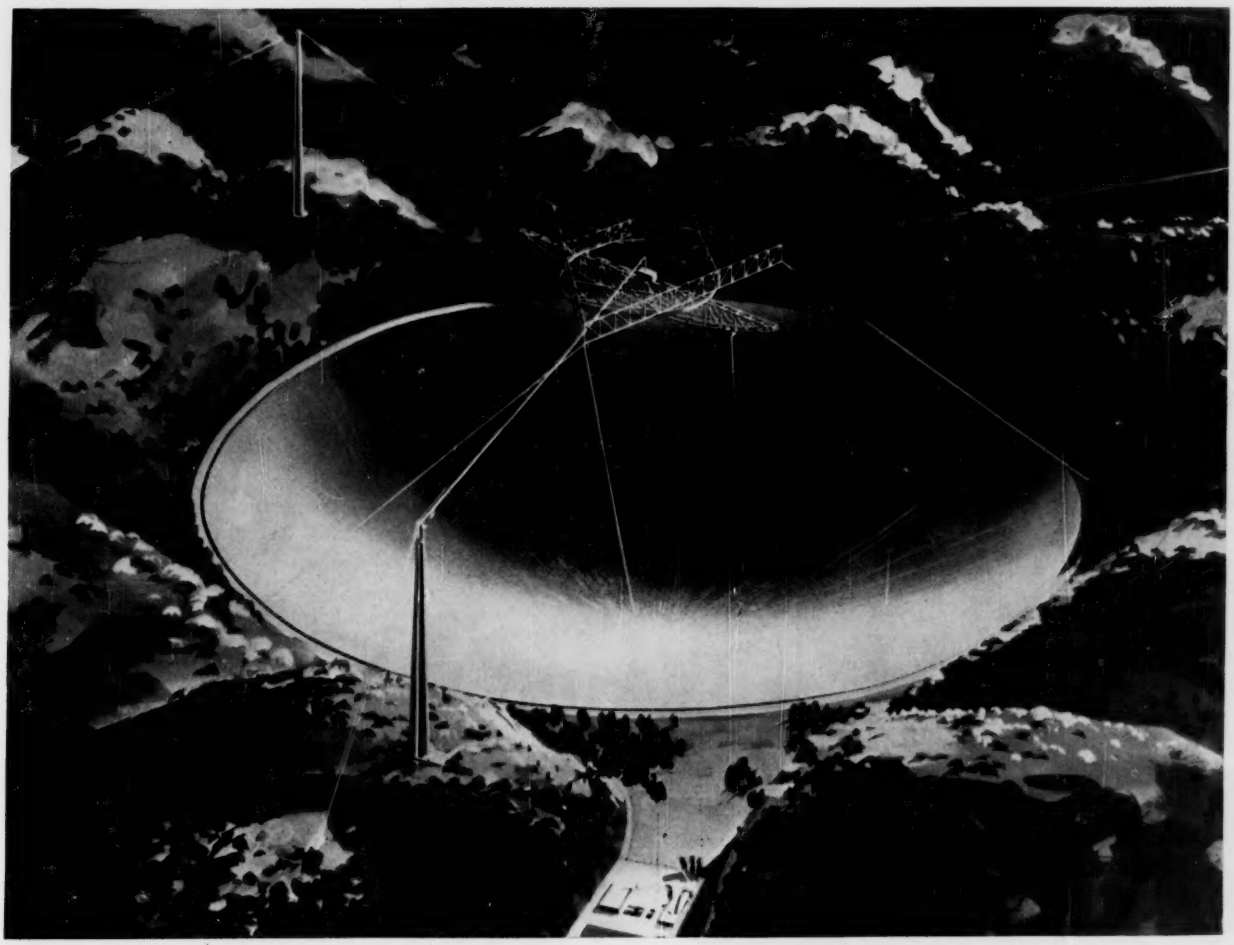
At Arecibo, Puerto Rico, the Department of Defense Ionospheric Research Facility is placing a 1,000-foot dish in a natural mountain-formed depression. The instrument will cost four million dollars.

The reflector mesh will be carried by a cable network with closely spaced supports and tie downs to maintain its contour within 0.1 foot of a spherical figure.

The complex feed system, seen in the picture below, is supported by a triangle of girders 216 feet on a side. With the reflector fixed, aiming at celestial objects and correction for spherical aberration must be accomplished at the feed. This five-ton assembly will be held accurately in place by three steel cables stretched between concrete towers, two of which are 265 feet high, the other 390 feet tall. The feed antenna can be moved over a spherical surface concentric with the main dish but having one half of its 870-foot radius of curvature. The primary lobe of the antenna can thus be swept over the area of sky that is within 20 degrees of the zenith. The beam-width is 10 minutes of arc.

Both installations have been designed for use as radar probes, and may be applied to exploration of the moon's surface, planetary atmospheres, and other celestial bodies. The Arecibo antenna, designed by Cornell University scientists, who are supervising its construction, will also be used for studies of the earth's upper atmosphere.

A service road and part of the huge excavation for the 1,000-foot radio reflector being built in Puerto Rico. The site is near the north coast of the island, about 40 miles west of San Juan.



An artist's conception of the Cornell-engineered spherical reflector and its antenna system. Courtesy Radiation, Inc.

NEWS NOTES

UNUSUAL NEW ECLIPSING STAR

During recent years, at Hamburg Observatory A. A. Wachmann has been carrying out a thorough photographic survey of variable stars in Cygnus. He uses the 12-inch Lippert astrographic camera, a 30-minute exposure reaching to photographic magnitude $16\frac{1}{2}$ or 17. Since the beginning of this program, nearly 300 new variables have been discovered and studied in detail, some of them on about 400 different plates.

In Dr. Wachmann's latest report, perhaps the most interesting of his new discoveries is the faint star HBV (Hamburg-Bergedorf Variable) 242. It is an Algol-type binary, with a range of 12.35 to 12.95 in photographic magnitude, and a period of 6.26 days. In each cycle, two minima of equal depth occur.

The noteworthy feature of this eclipsing system is that the secondary minimum does not occur midway between consecutive primary minima, but is displaced, indicating an eccentric orbit. Moreover, this displacement is slowly changing, showing that the direction of the long axis of the orbit is turning. Dr. Wachmann deduces from his 390 photographic observations that the eccentricity of the orbit is close to 0.20, and that the direction of the line of apsides changed by 12 degrees between 1950 and 1959. Hence the apsidal motion will amount to a whole revolution in about three centuries.

The relatively few eclipsing binaries known to exhibit apsidal motion are of special importance, because the rate of such motion can tell us about the internal structure of the component stars. If they are highly condensed toward their centers, the apsidal shift is slower than if they are of nearly uniform density.

HBV 242 is located not far from Beta Cygni, at $19^h\ 33^m.5$, $+26°\ 10'$ (1950 coordinates). Dr. Wachmann's report on it appears in Vol. 6, Part 1, of the *Astronomical Transactions* of Hamburg Observatory.

CLOUD SATELLITE OF THE EARTH

New observations are reported by K. Kordylewski, Krakow Observatory, of the very faint cloudlike natural satellite of the earth, which travels in the same orbit as the moon, but 60 degrees ahead of it, at the so-called L_4 point.

Details of the Polish astronomer's discovery of this object, as well as of a similar satellite at the L_5 point, 60 degrees following the moon, were given on page 63 in August, 1961.

In *Circular* 1779 of the International Astronomical Union, Dr. Kordylewski writes that in September an expedition was made to Kasprowy Wierch mountain in Czechoslovakia, for a visual, photographic, and photoelectric search. Preliminary results indicate that the L_4 object was detected on three nights as a pair of dim spots, each about five degrees in diameter and nearly touching.

MAN-IN-SPACE EXHIBITION IN NEW YORK CITY

Models of an orbiting space laboratory and a Mercury capsule are now on display in the Roosevelt Memorial Hall of New York's American Museum of Natural History. The full-scale mock-ups illustrate some proposed solutions to the problems of sustaining human life in space, and show the research methods and equipment spacemen may use.

Called Aries — for Authentic Representation of an Independent Earth Satellite — the 41-foot space laboratory is approximately the size of a four-room house. The aluminum cylinder is 15 feet in diameter and weighs more than five tons. It was designed by the Martin Co., and built with the aid of a $100,000 Martin educational grant to the museum. Admission to the exhibit is free.

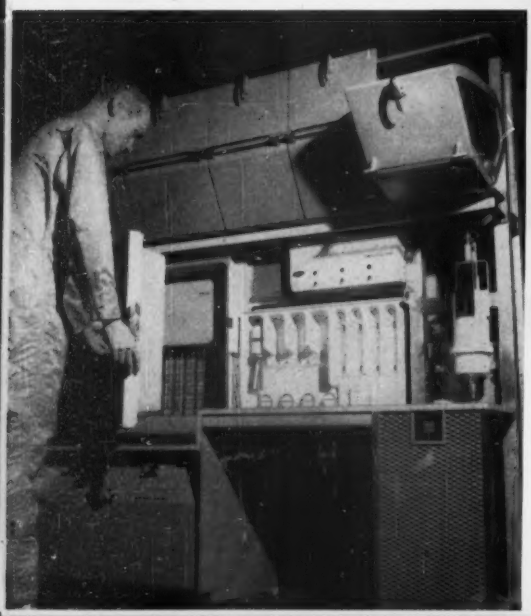
Cutaways and an open end enable visitors to view the laboratory's fully equipped compartments. Animal enclosures, hydroponic gardens, an astrophysical observatory, and facilities for biomedical studies are represented, staffed by dummy astronauts.

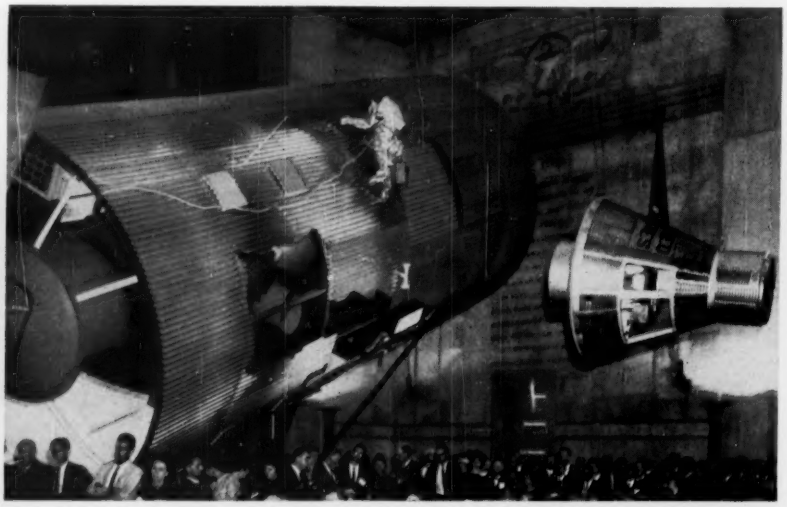
The Mercury spacecraft, similar to those used by Alan Shepard, Jr., and Virgil Grissom in their actual flights, was donated by the McDonnell Aircraft Corp., while the Air Force Museum lent a display of astronautical equipment.

IN THE CURRENT JOURNALS

GALACTIC STRUCTURE AT OPTICAL AND RADIO WAVE-LENGTHS, by Maarten Schmidt, *Journal* of the Royal Astronomical Society of Canada, August, 1961. "[There is a] close relationship between optical and radio astronomy in the field of galactic structure. Most information in optical astronomy deals with stars, in radio astronomy exclusively with the interstellar gas. We know that stars are formed out of the gas, and that evolving stars return part of their mass back to the interstellar medium."

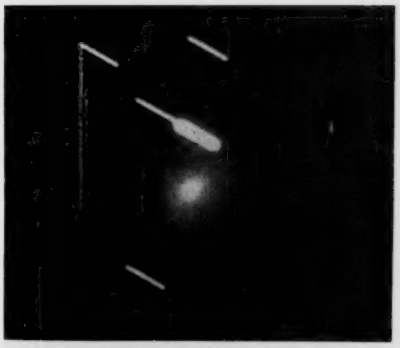
NEW FRONTIERS OF ASTRONOMICAL TECHNOLOGY, by Aden Baker Meinel, *Science*, October 20, 1961. "We can look for new methods enabling us to make better use of the starlight that is collected by our terrestrial telescopes, and we can also look to the new field, so challenging to astronomers, opened up by the development of aerospace technologies."





Above: The man-in-space exhibition at New York's American Museum of Natural History. At the left is the 41-foot model of an orbiting space laboratory; at the right, a full-scale replica of a Mercury capsule.

Left: The compact kitchen in the space laboratory. The white panel at right center contains individual feeding instruments to provide food under pressure during weightlessness. American Museum-Hayden Planetarium photographs.



Left: An outburst of Comet Schwassmann-Wachmann 1 is recorded on this 30-minute exposure taken October 18th with the 40-inch reflector by Elizabeth Roemer at Flagstaff, Arizona.

Right: Two other pictures by Dr. Roemer with the 40-inch telescope on October 2nd (top) and 4th show changes in Comet Humason. In each case the reproduction scale is 7.5 seconds of arc per millimeter. Official U. S. Navy photographs.

NEWS OF FOUR COMETS

(Continued from page 311)

as an object of magnitude 3 or 4 in the southern constellation Carina. Turning northward, by November's end it again is visible from mid-northern latitudes. Predicted 1950 co-ordinates and magnitudes are: November 22, $23^h\ 59^m$, $-38°.0$, 6; 27, $23^h\ 42^m$, $-30°.4$, $7\frac{1}{2}$; December 7, $23^h\ 34^m$, $-25°.0$, $9\frac{1}{2}$; 17, $23^h\ 35^m$, $-22°.5$, $10\frac{1}{2}$; 27, $23^h\ 38^m$, $-20°.9$, $11\frac{1}{2}$. On November 27th, small telescopes should show Comet Seki about 10 degrees east of 1st-magnitude Fomalhaut in Pisces Austrinus.

Though only of magnitude 14 when discovered on September 1st by Milton L. Humason, Comet 1961e promises to be of unusual interest. On that date it was as remote from the sun as Jupiter is. According to orbit calculations by B. G. Marsden, Yale Observatory, 1961e will continue to approach the sun until a minimum distance of about 200 million miles is reached on December 8, 1962. Hence this comet should brighten steadily for a year to come.

Early in September, Comet Humason was in Pisces, moving slowly toward the west and south. On September 9th, K. E. Kissell photographed it with the 16-inch Schmidt camera of Perkins Observatory at Delaware, Ohio, but was unable to see the comet through the 5-inch finder.

The total visual magnitude was 11.2 on October 2nd, according to Max Beyer, Hamburg Observatory. On the 7th, R. L. Waterfield, Ascot, England, found Comet 1961e "fairly easily visible" in his 6-inch refractor, and gave the magnitude as 11 or $11\frac{1}{2}$.

Most comets at great distances from the sun are merely starlike blobs, but Comet Humason showed unusual activity in October, as indicated by the accompanying pair of photographs by Dr. Roemer.

On October 2nd, she notes, the coma had a crablike shape, with faint evidence of material some five minutes of arc to the south and southeast. Two days later, the coma showed extensions in all directions, some sharp, others diffuse, and a contorted streamer was at least 15 minutes long on the original print. Photographs on October 12th and 15th indicated that this activity had diminished.

In December, Comet Humason should be visible in medium-size amateur telescopes in the southern sky during early evening hours. The following predicted right ascensions and declinations are for 0^h Universal time of the dates in question. They are taken from Mr. Marsden's ephemeris in Harvard *Announcement Card* 1546. The visual magnitude should be about $10\frac{1}{2}$.

November 27, $23^h\ 29^m.2$, $+17°\ 30'$. December 7, $23^h\ 23^m.6$, $+15°\ 36'$; 17, $23^h\ 19^m.8$, $+13°\ 55'$; 27, $23^h\ 17^m.8$, $+12°\ 28'$. January 6, $23^h\ 17^m.2$, $+11°\ 15'$.

In February, Comet Humason will be in conjunction with the sun and unobservable. During the spring and summer of 1962, it should be a conspicuous object in small telescopes, but then moving too far south to be seen from northern latitudes.

A third newsmaker is Periodic Comet Schwassmann-Wachmann 1, also known as 1925 II. It is noteworthy for traveling around the sun in a nearly circular path slightly larger than Jupiter's. Hence it can be observed in all parts of its orbit, as a planet can. Usually it is a faint object of about magnitude 18, but at irregular intervals it suddenly brightens in a short-lived explosive outburst.

Dr. Roemer's photograph of 1925 II on October 18th shows it while in such an active state. She writes that six days earlier the comet was stellar in appearance and at magnitude 13.

Although Comet 1961d (Wilson) was a spectacular naked-eye object soon after discovery in late July (see September issue, page 124, and October, 212), it has faded rapidly into insignificance. Dr. Roemer's photographs of it with the 40-inch Flagstaff reflector on September 30th showed merely a nearly stellar image of magnitude 18.4. Visually, it may have been somewhat brighter, but presumably by November Comet Wilson had grown too faint for even the largest telescopes.

829 COMET ORBITS

An enormous bulk of comet observations extending over 2,000 years has been concisely summarized in the 97-page *Catalogue of Cometary Orbits,* recently compiled by the computing section of the British Astronomical Association, under the direction of J. G. Porter. The publication consists mainly of a long table giving the most trustworthy orbital elements of comets from 240 B. C. to A. D. 1960.

Although there are 830 entries in the catalogue, Flaugergues' Comet 1826 III is identical with Biela's Comet 1826 I, as Dr. Porter points out. The sets of elements refer to 566 individual comets, of which 94 are short-period (under 200 years) and 116 long-period. Parabolic orbits are listed for 291 objects, hyperbolic for 65.

For each comet apparition, only one set of elements is given, chosen as the most accurate. Even so, there is an enormous range in reliability, from conjectural orbits of ancient Chinese comets to refined calculations for intensively observed recent objects. Hence the catalogue includes a note on each orbit's quality.

Much interesting information about periodic comets is tabulated in an appendix, including details of the motion of Comet Encke, which has been observed at 46 appearances between 1786 and 1961. The comet of longest period that has been observed at more than one apparition is Grigg-Mellish, which came to perihelion in 1742 and again in 1907.

Orders for the catalogue, at 15s (about $2.10) per copy, should be sent directly to the British Astronomical Association, 303 Bath Rd., Hounslow West, Middlesex, England.

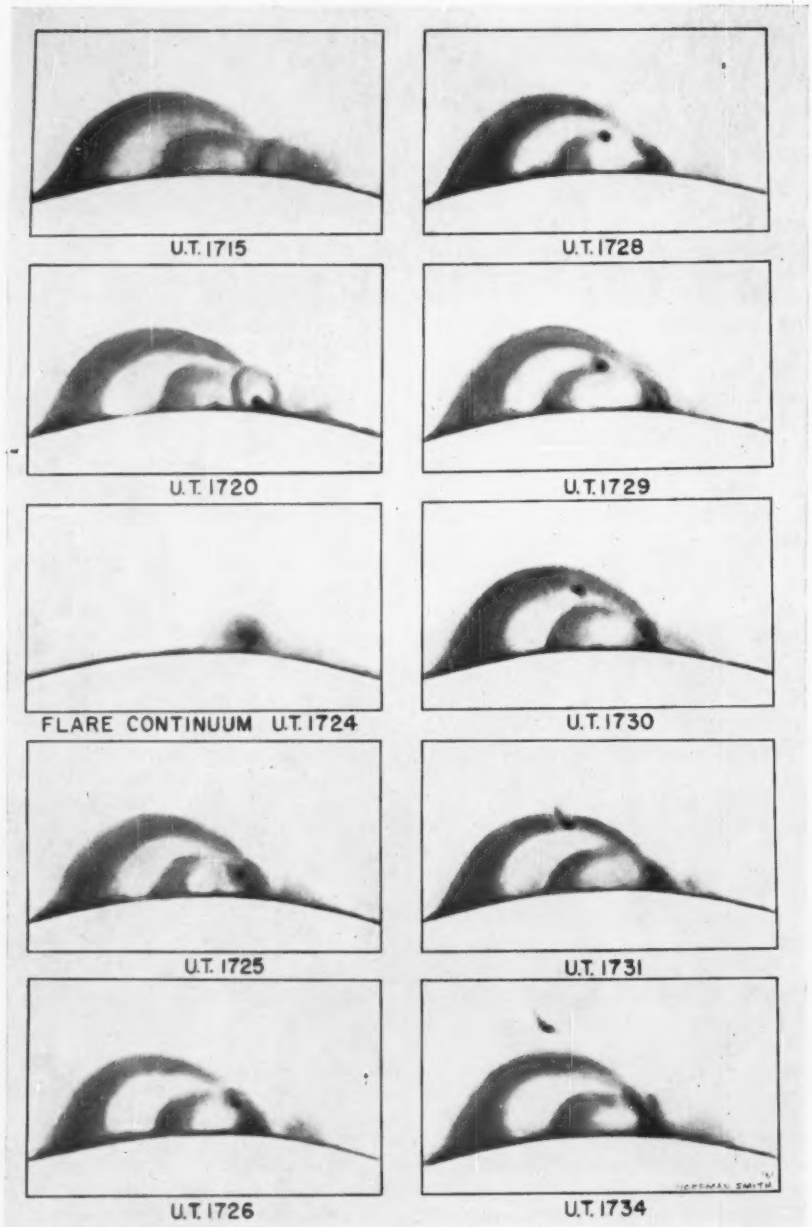
Passage of a Flare Spray Through the Solar Corona

FRANK Q. ORRALL and HENRY J. SMITH, *Sacramento Peak Observatory, U.S. Air Force*

CONCENTRIC arch structures have long been known to occur in the solar corona, and are seen in both white light and the forbidden emission line of iron at 5303 angstroms. For six years, monochromatic coronal forms and changes have been recorded at Sacramento Peak, New Mexico, by means of a 6-inch coronagraph and a Lyot birefringent filter having a two-angstrom bandpass.

During the course of these observations, on March 7, 1959, the passage of a flare-spray prominence through the corona was recorded. Flare sprays are among the most energetic solar phenomena detectable optically. According to J. W. Warwick, they are characterized by extraordinarily high speed, by clumpiness, and by virtually straight-line trajectories outward from a small center of origin in the flare. Sprays are rare events, and this is the first we have observed in relation to monochromatic coronal forms.

The illustration shows the phenomenon in selected scenes from the 76-frame motion picture taken that day between 16:32 and 18:14 Universal time. The limb flare began at about 17:15, at the base of the coronal arch. In this picture the flare is hidden by the coronagraph's occulting disk, but a series of bright shells can be seen in the corona above it, expanding away from the flare (17:20). The picture at 17:24 was made in the adjacent spectral continuum. Coronal structures have vanished, but the flare is seen, demonstrating that it is visible in continuous light rather than only the iron radiation. The arches and shell, on the other hand, must be structures in the million-degree corona.



Pencil drawings by Mrs. Margaret Smith from Sacramento Peak negatives.

The flare spray moves along the inner arch from 17:25 to 17:29; then it leaves this constrained trajectory and follows a roughly rectilinear path across the outer arch. Throughout the event the coronal arches remained unchanged. The spray had an average velocity of 240 kilometers per second on the more sharply defined hydrogen-alpha pictures (0.5-angstrom flare patrol), but fainter portions of it may have moved more rapidly.

Perhaps the chief interest of this event lies in the associated radio-frequency observations, kindly communicated by Alan Maxwell from the radio astronomy station of Harvard Observatory at Fort Davis, Texas. During the course of this event, there occurred a number of type-III bursts, a faint slow-drift burst, and a "U-burst" (SKY AND TELESCOPE, June, 1958, page 392). The first type-III radio disturbance recorded that day began abruptly at about 100 megacycles per second, the time being 17:24 UT.

Simultaneously, the shell preceding the flare was at a height where the plasma frequency was 100 megacycles, as computed from the probable electron density. Of course the shell moved far too slowly to be identified directly with the burst, but the observations suggest that the shell may have generated the disturbance that gave rise to the radio noise. Similarly the weak slow-drift burst has an inferred velocity 50 per cent greater than that of the flare spray. However, the measured 240 kilometers per second of the spray is only a lower limit, and the radio-drift velocity is deduced from a density gradient that may be only approximate.

The U-burst took place at 17:47, and showed a frequency inversion at 30 megacycles per second, which corresponds to a much greater height than we observed. However, Dr. Maxwell and G. Swarup have suggested that these bursts might be radiation from a disturbance constrained to move over a curved path. We propose that one of the outer concentric coronal arches was the path taken by the disturbance causing the U-burst.

ASTRONOMICAL SCRAPBOOK

The Great September Comet of 1882

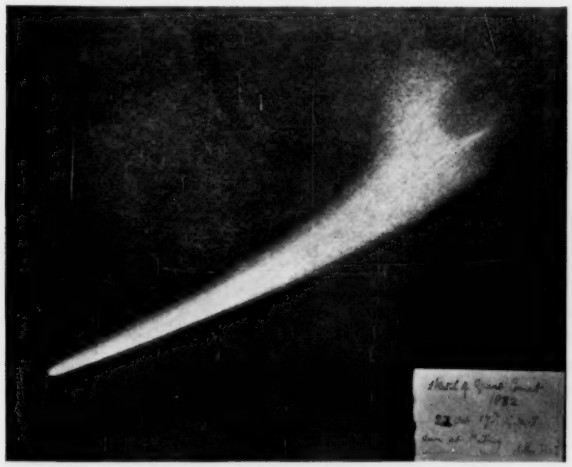
In 1950, Dorrit Hoffleit published a pamphlet, *Some Firsts in Astronomical Photography,* which contains much interesting information about the earliest efforts to take pictures of celestial objects. Miss Hoffleit tells us that the first comet photograph ever made was one of Donati's comet in 1858, by the English amateur Usherwood.

This must have been a noteworthy feat in those days when the exceedingly slow daguerreotype process was being replaced by the faster but inconvenient wet plate, with which only short exposures were feasible. Usherwood's achievement was probably made possible only by the great brightness of Comet Donati. With the invention of gelatin dry plates in the 1870's, long exposure times became common, and a spectacular advance in celestial photography began. The first application of the dry plate to astronomy was a spectrogram of Vega taken by William Huggins in 1876.

According to Agnes M. Clerke's *A Popular History of Astronomy During the Nineteenth Century,* Tebbutt's Comet 1881 III was the first of which a satisfactory photograph was obtained. In the following year, one of the most brilliant comets of modern times appeared. Many persons in the Southern Hemisphere independently discovered it during early September, 1882, as a naked-eye object in the morning twilight. Comet 1882 II brightened rapidly as it approached perihelion on the 17th of that month, and passed only 305,000 miles from the sun's surface. In a few hours the comet moved across the solar disk, reached elongation, and traveled westward behind the sun.

David Gill, director of the Cape Observatory in South Africa, described the splendor of the comet as it came above the horizon on the following morning. "The Sun rose a few minutes afterwards, but to my intense surprise the comet seemed in no way dimmed in brightness, but becoming instead whiter and sharper in form as it rose above the mists of the horizon." Later in the morning, "It was only necessary to shade the eye from direct sunlight with the hand at arm's-length to see the comet with its brilliant white nucleus, and dense white, sharply-bordered tail of quite ½° in length."

During the remainder of September and in October, the comet continued as a spectacular feature of the morning sky. At Vizagapatam, India, one amateur astronomer described the tail as shaped like the tusk of an elephant. As seen with the naked eye, the whole tail took nearly an hour to rise above the sea horizon.



A drawing of the great comet of 1882, made by John Brett at Putney, England, on October 22nd that year, at 5 p.m. Greenwich time. He used binoculars for this observation. Reproduced from a photographic copy in "Monthly Notices" of the Royal Astronomical Society.

The best-known photographs of 1882 II are those taken by Gill that October and November. He used an ordinary camera with a portrait lens of 2½-inch aperture and 11-inch focus, attached to the declination counterweight of the Cape Observatory's 6-inch refractor. Guiding on the comet's nucleus, he obtained exposures, one as long as two hours 20 minutes, on six different nights. Prints of his pictures were sent to the Royal Astronomical Society in London.

Gill's pictures were of historic importance because of the unexpected number of stars they showed. It was this circumstance that led him to undertake the *Cape Photographic Durchmusterung,* in collaboration with J. C. Kapteyn.

In Australia, R. L. J. Ellery of Melbourne Observatory was experimenting with many kinds of astronomical photography. He was taking plates of the moon and the Orion nebula with the 48-inch reflector, and a systematic photographic record of sunspots was maintained. In his annual report for 1882-83, Ellery says that some exposures were made on the great comet of 1882, "with more or less success."

Also at Melbourne, an unnamed local photographer obtained a picture of the comet on October 10, 1882. A print was forwarded by Ellery to the Royal Astronomical Society, but it was noted, "The camera in this instance was not equatoreally mounted, and the nucleus of the comet is therefore very much elongated."

It is to be expected that other now-forgotten pictures of 1882 II were taken. One of these has recently appeared from oblivion, and is reproduced below through the kindness of Lawrence H. Aller, University of Michigan Observatory. He was given this photograph by A. R. Hogg of Mount Stromlo Observatory in Australia, who had received it from Mrs. G. W. Wright, Goulburn, New South Wales.

The only information Mrs. Wright could furnish is that the photograph shows the great comet of 1882, and that

This photograph of the great September comet of 1882 is among the first ever made of this kind of celestial object. It was taken in Australia by an unidentified photographer, probably at Bombala, New South Wales.

it came from Bombala. This is a small town in New South Wales, a little inland from the Pacific Ocean and close to the boundary of Victoria. Perhaps it may still be possible to ascertain the name of a photographer or amateur astronomer who lived there some 80 years ago.

Unfortunately the photograph has little or no scientific value because it has apparently been extensively retouched. The original print shows many fine brush marks in the comet tail, whose edges seem to have been sharpened. Nevertheless, the picture is of some historic interest in recalling the impression made by a remarkable sight in the dawn sky of late 1882.

The great September comet is a tantalizing object to present-day astronomers, because it appeared several decades too soon for its unusual phenomena to be studied with modern techniques. Unlike ordinary comets, 1882 II had a spectrum featuring many bright lines of sodium, iron, and nickel, when it was very close to the sun. Only crude visual observations could be made of this unusual spectrum, which now would deserve study with powerful coude spectrographs.

Modern coronagraphs and other refined instruments for solar observation would be called into play today to study a phenomenon like the transit of Comet 1882 II across the sun's disk that September 17th. But the rare event was observed visually at the Cape Observatory by W. H. Finlay and by W. L. Elkin.

The former's account is worth quoting: "In the afternoon I watched the comet with the 6-inch equatorial, and power 110, using a neutral-tint wedge on account of the glare of the Sun. I did not expect that the comet would reach the Sun before night, but they were rapidly approaching one another, and about 4:40 p.m. I found the Sun's limb visible at the edge of the field. The silvery light of the comet presented a striking contrast to the reddish-yellow of the Sun; the tail could be traced to only a very short distance now. . . .

"By keeping the Sun's limb at the edge of the field I was able to follow the comet continuously right into the boiling at the limb. I lost sight of it suddenly at $4^h\ 50^m\ 58^s$ Cape mean time. . . . I then examined the Sun's disk very carefully, but could not see the slightest trace of the comet. . . . The sun was then very low and the definition bad." This account agrees in detail with Elkin's simultaneous findings with another telescope, his time of disappearance being only eight seconds earlier.

This exceptional observation is of great importance in modern thinking about the constitution of comets. But in drawing inferences from the nonvisibility of the nucleus against the solar background, astronomers have not always recalled how unfavorable the observing conditions were. The next opportunity of this sort deserves full exploitation.

JOSEPH ASHBROOK

OBSERVING THE SATELLITES

Notes on Discoverers

THE 22nd Discoverer satellite to attain orbit was launched from Vandenberg Air Force Base, California, on October 13, 1961, at about 19:22 Universal time. Slightly more than a day later, during the 18th revolution, its capsule was released and later caught in flight by a C-130 recovery plane near Hawaii, at 23:07 UT. This was the program's ninth successful recovery, and the sixth in midair.

The capsule of Discoverer XXXII contained samples exposed for 27 hours to the radiation in nearby space. Various metals and other materials were aboard to show their response to irradiation and to test their effectiveness as shields. The payload included dosimeters and a nuclear block emulsion. Seed corn was carried for a biological experiment.

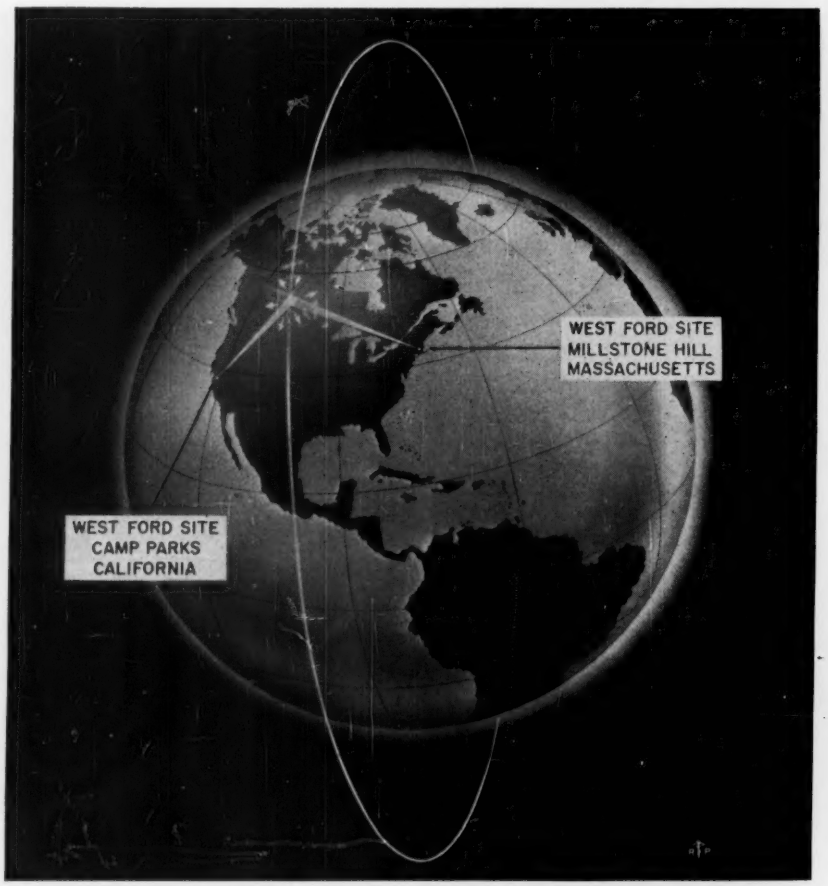
After the capsule separated, the Agena remained in orbit, transmitting 20.05-megacycle signals for a study of radio propagation in the ionosphere.

Two additional components, 1961$\alpha\gamma$2 and $\alpha\gamma$3, were found to be in short-lived orbits inclined about 81.7 degrees to the earth's equator, and descended on October 25-26 and October 16th, respectively.

As noted in this magazine last January (page 13), the launching of the satellite Discoverer XVII on November 12, 1960, coincided with the eruption of a very intense solar flare. During its two days in orbit around the earth, the 300-pound capsule was subjected to extraordinarily heavy bombardment by particles expelled from the sun. A sample of the capsule material has now been analyzed at the Smithsonian Astrophysical Observatory by E. L. Fireman, J. DeFelice, and D. Tilles.

They find 100 times more tritium — the radioactive hydrogen isotope of atomic mass 3 — in Discoverer XVII than in other capsules with similar orbits but that have not been subjected to the effects of flares. The excess amount was concentrated near the surface of the sample, so these scientists conclude that the November flare itself must have supplied the tritium.

In terrestrial experiments with a small cyclotron, tritium can be formed by combining hydrogen and helium nuclei at energies of more than a million electron volts. Apparently in solar flares highly accelerated particles of these same elements collide to produce significant quantities of tritium which reach the earth.



In this artist's drawing of the polar orbit sought for the "needles" of the Project West Ford experiment, an example of the method of long-distance microwave communication is depicted. Courtesy Lincoln Laboratory.

Midas IV and Project West Ford

ON OCTOBER 21st about 13:53 UT, the experimental launch-detecting satellite Midas IV was sent aloft by the U. S. Air Force. It carried a package of test "needles" for Project West Ford, a proposed system of long-range communication. The plan calls for a belt of tiny orbiting wires, which would scatter microwaves from a ground radio transmitter, allowing the signals to be picked up by a distant receiver.

In this launching, a 130-ton modified Atlas-D rocket rose from Point Arguello, California, with a total thrust of some 360,000 pounds. The second-stage Agena B fired briefly after the Atlas separated, developing a 15,000-pound thrust to attain a highly elliptical orbit. Near the apogee of the first circuit, its engine was started again to make the path nearly circular. This launching maneuver was previously used for Midas III, as described on page 145 of the September, 1961, issue.

Details of the final orbit of Midas IV have not been officially announced at the time of writing (November 4th). Statements before the launching indicated an intended period of 172 minutes. This corresponds to a mean height of some 2,800 miles, well above the 2,140 of Midas III.

The infrared detection system carried by Midas IV was tested successfully. On October 24th a Titan missile was fired from Cape Canaveral while the Midas was above the horizon. On a later revolution, when the Midas was within range of Vandenberg Air Force Base, it reported detecting the Titan's hot exhaust. No details of the infrared sensors are available.

Many astronomers have feared that optical and radio observations may be hindered by the orbiting needles of Project West Ford, and space scientists have wondered about collisions of the fast-moving wires with manned spacecraft. Criticisms voiced by the International Astronomical Union (see October, 1961, issue, page 188) and other groups were considered by a special panel of the President's science advisory committee. The panel concluded that the small amount of material in this trial package would neither impair "ability to study the skies" nor be a hazard to spaceflight. The first test was made with assurances that its results would be studied thoroughly before any more wires were put into orbit.

The needle package was a 15-inch stack of disks 5½ inches in diameter. Each disk was 0.7 inch thick, containing copper wires 1.77 centimeters long and 0.00286 in diameter. These were arranged parallel to the axis of the assembly and embedded in naphthalene.

This should vaporize gradually in space, freeing the wires. Since the dispenser was to rotate 400 times a minute, the wires would be flung out at speeds up to 10 feet per second.

The 35 kilograms of needles, each weighing only 0.1 milligram, were expected to spread into a continuous band around the earth within some three weeks after launching. In a few months the belt would be about five miles wide and 25 deep.

For the communication tests, two 60-foot transmitting antennas are located at Westford, Massachusetts, and near San Francisco, California. Their beam-widths are nine minutes of arc at the resonant frequency of the needles, about 8,500 megacycles per second.

So far, neither radar nor optical detection of the dispenser or belt has been reported. Telemetry from the Agena B had indicated that the package was ejected at the expected time and proper speed.

Fourth Year of the Space Age

THE SPACE PROGRAMS of the United States and the U. S. S. R. are both moving at an increasing pace, though major innovations are becoming rarer. This is the broad conclusion from the table on the following pages, which is a review of all known launchings during the year that began on October 4, 1960. Earlier surveys were given in this department of Sky and Telescope in November, 1959, page 12, and November, 1960, page 274.

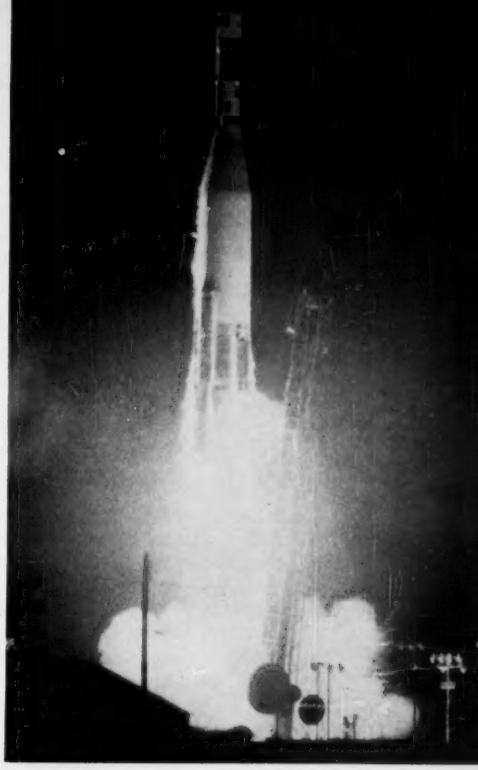
Recently, the Space Operations Control Center of NASA has assigned Greek-letter designations retroactively to all previously unlabeled objects that remained in flight 90 minutes or longer. The United States has made 54 of these successful shots, 26 of them in the year under review, and for the Soviet Union these numbers are 15 and seven. Thus, in both countries nearly half of all successful shots were made during the fourth year of the era that began with Sputnik I on October 4, 1957.

Relatively few of these latest launchings have marked the beginnings of new programs. The announced purposes indicate that most recent firings are being made to explore more deeply problems already touched upon in earlier work.

In the American program, improved reliability has been stressed more than novelty. In the period covered by the table, 65 per cent of the firings sent payloads into orbit; previously the figure was 51 per cent. Many of the recent successes have been achieved with Thor boosters. This Air Force rocket earned a Greek letter in 18 of 24 attempts. The most successful configuration, with no failures in four tries during the year, has been the Thor-Delta, with upper stages adapted from the old Vanguard program.

The changes given below are needed in our earlier lists, to bring them up to date and to show the new Greek-letter designations.

A review of the statistics shows that as of October 4, 1961, there were 27 objects known to have remained for over a year in orbit around the earth, four of



The Atlas-Agena-B rocket combination, taking off from Point Arguello on October 21st, carried into orbit the Midas IV satellite and the package of fine wires for Project West Ford. Photograph from U. S. Air Force.

CHANGES FOR EARLIER SATELLITES

Name	*Designation*	*Remarks*
Pioneer I	1958η	High trajectory
Pioneer III	1958θ	High trajectory
Discoverer V capsule	1959ε2	Down Feb. 11, 1961
Mechta	1959μ	Solar orbit
Pioneer IV	1959ν	Solar orbit
Lunik II	1959ξ	On moon
Transit I-B rocket	1960γ1	Down Aug. 18, 1961
Transit I-B part	1960γ3	Down July, 1960
Sputnik IV rocket parts	1960ε5, 6, 8, 9	Down Sept.-Oct., 1960
Midas II	1960ζ1	Radio dead by July, 1961
Midas II part	1960ζ2	Down Dec. 5, 1960
Greb	1960η2	Radio shut off April, 1961
Discoverer XIII	1960θ	Down Nov. 14, 1960
Echo I	1960ι1	Radio dead by March, 1961
Discoverer XV	1960μ	Down Oct. 18, 1960

AMERICAN AND SOVIET LAUNCHINGS OF SATELLITES AND

Launched	*Site**	*Vehicle†*	*Name*	*Designation*	*Major Programs*	*Weight (pounds)*	*Shape***
1960 Oct. 4	C	T-s	Courier I-B	1960ν1	Communications repeater	500	s
11	P	A-a	Samos I		Develop reconnaissance	4,100	c
26	V	T-b	Discoverer XVI		Test new Agena-B stage	2,100	c
Nov. 3	C	J-j	Explorer VIII	1960ξ1	Ionosphere, micrometeorites	90	bc
12	V	T-b	Discoverer XVII	1960o	Recover biospecimens	2,100	c
23	C	T-d	Tiros II	1960π1	Cloud TV, infrared	280	d
30	C	T-s	Transit III-A		Navigation, solar radiation	203	s
Dec. 1	R		Spacecraft III	1960ρ1	Check life-supporting equipment	10,060	
4	W	S-c	S-56 (Explorer)		Scout development, balloon drag	14	s
7	V	T-b	Discoverer XVIII	1960σ	Recover radiation experiments	2,100	c
15	C	A-v	Atlas-Able 5-B		Pioneer lunar probe	388	s
20	V	T-b	Discoverer XIX	1960τ	Infrared experiments for Midas	2,100	c
1961 Jan. 31	P	A-a	Samos II	1961α1	Develop reconnaissance	4,100	c
Feb. 4	R		Sputnik VII	1961β1	Heavy body in precise orbit	14,293	
12	R		Venus probe	1961γ1	Interplanetary and Venus observations	1,419	c
16	W	S-c	Explorer IX	1961δ1	Air-drag balloon	15	s
17	V	T-b	Discoverer XX	1961ε1	More revolutions before recovery	2,450	c
18	V	T-b	Discoverer XXI	1961ζ	Infrared experiments for Midas	2,100	c
22	C	T-s	Transit III-B	1961η	Navigation, low-frequency test	1,600	i
25	C	J-j	S-45 I (Explorer)		Ionosphere sounding	74	bc
Mar. 9	R		Spacecraft IV	1961θ1	Test ship for man orbit	10,360	
25	R		Spacecraft V	1961ι1	Test ship for man orbit	10,360	
25	C	T-d	Explorer X	1961κ	Cislunar magnetometer, plasma	78	i
30	V	T-b	Discoverer XXII		Recover radiation detectors	2,100	c
Apr. 8	V	T-b	Discoverer XXIII	1961λ1	Test Agena improvements	2,100	c
12	R		Vostok I	1961μ1	Single revolution of manned vehicle	10,417	
25	C	A-m	Mercury-Atlas 3		Recover Mercury capsule	2,700	b
27	C	J-j	Explorer XI	1961ν	Gamma-ray astronomy	95	c
May 24	C	J-j	S-45 II (Explorer)		Ionosphere sounding	74	bc
June 8	V	T-b	Discoverer XXIV		Test recent improvements	2,100	c
16	V	T-b	Discoverer XXV	1961ξ	Recover irradiated metals	2,100	c
29	C	T-s	Transit IV-A	1961o1	Navigation, cosmic rays, X-rays	175	d
30	W	S-c	S-55 (Explorer)		Micrometeorite detectors	187	c
July 7	V	T-b	Discoverer XXVI	1961π	Refine launch and recovery	2,100	c
12	C	T-d	Tiros III	1961ρ1	Cloud TV, infrared	285	d
12	P	A-b	Midas III	1961σ1	Detect missile launchings	3,500	c
21	V	T-b	Discoverer XXVII		Improve reliability	2,100	c
Aug. 4	V	T-b	Discoverer XXVIII		Control orbital period	2,100	c
6	R		Vostok II	1961τ1	Man in orbit full day	10,430	
16	C	T-d	Explorer XII	1961υ	Cislunar fields and particles	83	i
23	C	A-b	Ranger I	1961ϕ1	Translunar probe checkout	675	i
25	W	S-c	Explorer XIII	1961χ	Micrometeorite sensors	187	c
30	V	T-b	Discoverer XXIX	1961ψ	Improve control components	2,100	c
Sept. 9	P	A-b	Samos III		Develop reconnaissance	4,200	c
12	V	T-b	Discoverer XXX	1961ω1	Improve impact prediction	2,100	c
13	C	A-m	Mercury-Atlas 4	1961$\alpha\alpha$1	Check life-support system	2,700	b
17	V	T-b	Discoverer XXXI	1961$\alpha\beta$1	Test advanced components	2,100	c

*Under *Site*, C, P, V, and W designate American launchings from Cape Canaveral, Florida; Point Arguello, California; Vandenberg Air Force Base, California; and Wallops Station, Virginia, respectively. R is for Soviet launchings from unspecified sites, although Baikonur, near the Aral Sea, has been revealed as the Vostoks' firing location.

†Under *Vehicle*, booster rockets are A, Atlas; J, Jupiter; S, Scout's Algol; T, Thor. Upper stages are designated by a, Agena A; b, Agena B; c, Scout's upper stages; d, Delta configuration; j, Juno high-speed cluster; m, Mercury capsule; s, Able-Star; v, Able.

**Under *Shape*, each object is described by b for bell; bc, biconical; c, cylinder; d, drum; i, irregular; s, sphere.

them with radio transmitters still operating. In addition, Lunik I, Pioneer IV, and Pioneer V — all launched in 1959 or early 1960 — were traveling around the sun.

The total number of known components in orbit has jumped greatly. There were 66 such objects in Air Force listings for the first three years of space shots, including 11 whose existence was confirmed only many months after launching. The fourth year added at least 121 known objects — satellites, rockets, and fragments. Much of this upswing has come from increased sensitivity of tracking equipment, and from the disintegration of Transit IV-A's rocket into 50 or more parts.

The present table has been compiled with the assistance of Mrs. W. R. Battersby, of the Research Station for Satellite Observation. Information was supplied largely by the National Aeronautics and Space Administration and by the North American Air Defense Command. Russian press announcements were the major source of data concerning the Soviet space program, but they omit launching failures.

All dates in the table are expressed in Universal time. The major payload in each case is assigned the number 1, and unless otherwise specified the rocket is numbered 2.

PROBES DURING THE FOURTH YEAR OF THE SPACE AGE

Length (feet)	*Diameter (feet)*	*Status*	*Recovery Tries*	*Notes‡*	*Other Facts*
—	4.3	1960ν1-2 in orbit			107.9709-mc. radio operating
22	5	Failed			Agena misfired after separation
25	5	Failed	No orbit		Stages failed to separate
2.5	2.5	1960ξ1-4 in orbit			Radio silent Dec. 27, 1960
25	5	Down Dec. 29, 1960	Midair, Nov. 14, 1960		Solar flare while in orbit
1.5	3.5	1960π1-4 in orbit			108.0- and 108.3-mc. radios operating
—	3	Failed		1	Thor quit early; destroyed on command
		1960ρ1-2 down Dec. 2, 1960	Burned Dec. 2, 1960	2	Down along "noncalculated trajectory"
—	12	Failed			Second stage failed to ignite
25	5	Down Apr. 2, 1961	Midair, Dec. 10, 1960		Thor thrust increased 10 per cent
—	3.3	Failed			Atlas exploded eight miles up
25	5	Down Jan. 23, 1961	No capsule		Transmitted for 75 revolutions
22	5	1961α1-2 in orbit			Predicted radio lifetime 20 days
				3	Probable rehearsal for subsequent shot
6.7	3.4			4	Last heard Feb. 27, 1961, 4,700,000 miles distant
—	12	1961δ1-4 in orbit			Balloon radio failed, rocket radio operating
25	5		Capsule in orbit	5	Malfunction prevented re-entry
25	5	In orbit	No capsule		Agena-B restarted in orbit
20	4±	Down Mar. 30, 1961		6	Payloads never parted from rocket
2	2.5	Failed			Third and fourth stages failed to ignite
			Recovered Mar. 9, 1961	7	Chernushka and other animals
			Recovered Mar. 25, 1961	8	Zvezdochka and other animals
4.3	1.5	Probably in orbit			Good telemetry for 60 hours
25	5	Failed	No orbit		"Mechanical malfunction"
25	5		Capsule in orbit	9	Orientation off when capsule separated
			Gagarin landed	10	108-minute manned orbital flight
9	6	Failed	No orbit		Atlas departed from preset path
7.3	<1	In orbit			108.058-mc. radio operating
2	2.5	Failed			Second-stage ignition failed in Juno
25	5	Failed	No orbit		Second-stage ignition failed in Agena
25	5	Down July 12, 1961	In sea, June 19, 1961		Orbit terminated for weather
2.6	3.6			11	54-mc. radio for 1961o1 and 136.5-mc. for o2 operating
6.3	2	Failed			Third-stage ignition failed in Scout
25	5	In orbit	Midair, July 10, 1961		Agena also had scientific telemetry
1.5	3.5	1961ρ1-4 in orbit			108.0- and 108.03-mc. tracking frequencies
30	5			12	High-perigee circular orbit
25	5	Failed	No orbit		Veered off course; destroyed on command
25	5	Failed	No orbit		Agena failed to develop velocity
			Titov parachuted	13	More than 17 revolutions
1.6	2.3	In orbit			136.020-mc. radio transmitting data
11	5			14	Attained low orbit
6.3	2	Down Aug. 28, 1961			Attained low orbit
25	5	Down Sept. 9 or 10, 1961	In sea, Sept. 1 or 2, 1961		Impact 100 miles from plan
25	5	Failed			Exploded on launch pad
25	5		Midair, Sept. 14, 1961	15	
9.5	6		In sea, Sept. 13, 1961	16	Down-range and communication check-out
25	5	In orbit	No separation		

‡*NOTES TO TABLE*

1. Transit III-A was sent up with a 40-pound, 1.7-foot sphere, Solar Radiation II.

2. Also called Sputnik VI.

3. An improved multi-stage rocket was used. 1961β1 came down Feb. 26, 1961; β2, down Feb. 12 or 13; β3 (shroud), down Mar. 17.

4. An improved multi-stage rocket was used. 1961γ1 is in solar orbit; γ2, down Feb. 18, 1961; γ3 (the orbiting platform), down Feb. 25; γ4, down between Feb. 13 and 18.

5. 1961ε1 (Agena) and ε4 (capsule) are in orbit; ε2, down between Mar. 30 and Apr. 2; ε3, down Apr. 20.

6. Lofti, a 57-pound, 1.7-foot sphere, remained attached to Transit III-B (a 250-pound, three-foot sphere), and to the Able-Star rocket.

7. Also called Sputnik IX. 1961θ1 was recovered Mar. 9; θ2 and θ3, down Mar. 10.

8. Also called Sputnik X. 1961ι1 was recovered on Mar. 25; ι2 and ι3, down Mar. 26.

9. 1961λ1 (Agena) and λ2 (capsule) are in orbit; λ3, down Sept. 10.

10. Also called Spacecraft VI. 1961μ1 was recovered Apr. 12; μ2, down Apr. 16. Vostok I had six engines, totaling 20,000,000 horsepower.

11. Two satellites, which remained joined together as 1961o2, accompanied Transit IV-A. These were Solar Radiation III, a 55-pound sphere, 1.7 feet in diameter, and Injun, a 40-pound cylinder, 1.1 feet high and 1.3 feet in diameter. 1961o1 is Transit IV-A; o3 through o52 (fragments of the rocket) are in orbit.

12. 1961σ1 is in orbit; $\sigma\hat{2}$ (metal object) came down July 24; after Oct. 4 more parts, σ3 and σ4, were recognized.

13. 1961τ1 was recovered Aug. 7; τ2, down Aug. 9.

14. 1961ϕ1 is reported to have come down Aug. 30; ϕ2, down Sept. 3.

15. 1961ω1 is in orbit; ω2 and ω3 (minor parts), down Sept. 18 and 28, respectively.

16. 1961$\alpha\alpha$1 was recovered Sept. 13; $\alpha\alpha$2, down same day.

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Amateur Astronomers

A Teaching Observatory in the Netherlands

ON JANUARY 14th, this year, Dr. M. G. J. Minnaert of Utrecht Observatory officiated at ceremonies opening the Simon Stevin Observatory, in Oudenbosch, 20 miles south of Rotterdam. The observatory is the result of an interest in astronomy that started with my first telescope, built when I was 14 years old.

Simon Stevin (1548-1620) was born in Brugge, Belgium, and became an engineer to the court of Prince Maurice of Orange. At a time when advanced schools and textbooks used the Latin language, he founded an engineering department at the University of Leiden where all lessons were given in Dutch. Many of his books on mathematics, mechanics, hydrostatics, military engineering, astronomy, navigation, bookkeeping, music, and politics were also written in the common language. Because of his striving to educate the general public, it was fitting to name after him the first observatory in the Netherlands devoted entirely to teaching astronomy.

Atop one of the buildings of the Sancta Maria grammar school, where I teach mathematics, we have two balconies for astronomical observing, each 12 feet square. Between them is a tower containing a somewhat larger room we use for slide shows and lectures. Our main instrument is a 5-inch refractor with a 4-inch finder. In addition, there is a teaching telescope with a double eyepiece so that both visitor and instructor may view an object simultaneously, some smaller refractors, an astro compass, and a mirror sextant. Many celestial photographs taken with the world's largest telescopes are displayed in illuminated cases.

Every clear evening, 10 to 15 persons who have previously made reservations visit the observatory for an hour-long program. During the first 30 minutes they are told about the transparencies and the objects later to be viewed in the telescopes.

Although the Simon Stevin Observatory is intended primarily for the population of our immediate region, West Brabant, people from all parts of our country have visited it, due to wide newspaper publicity. There is far more interest in astronomy than we expected, and we have a waiting list with hundreds of names on it. Other Dutch amateurs have also been thinking about setting up teaching observatories; so far I have learned that two such installations are in progress.

BRUNO ERNST
Simon Stevin Observatory
Bosschendijk 2
Oudenbosch, Netherlands

The Simon Stevin Observatory in Oudenbosch, Netherlands, is open every clear evening from October to April. Inspecting a teaching telescope at dedication ceremonies last January are, from left to right, Dr. J. Raimond, chairman of the Dutch Amateur Astronomical Society; Dr. M. Minnaert, Utrecht Observatory; and Bruno Ernst, director of Simon Stevin. "De Telegraaf" photo.

+++ Amateur Briefs +++

On nights near meteor shower maxima, David W. Balsiger of Juda, Wisconsin, sleeps outdoors, to be ready for early-morning observations. This year, from his comfortable observing position, he counted 272 meteors in $6\frac{2}{3}$ hours on seven nights during the Perseids. He also watched for Draconids on October 8th and Orionids on the 18th.

Members of the Amateur Astronomers Association of Pittsburgh, Pennsylvania, were saddened to learn of the death of Chester B. Roe, organizer and first president of their society.

Jim Nakashima, a Dubuque, Iowa, junior astronomer, has a favorite mnemonic to recall the names of the planets in order from the sun: "Many very early men ate juicy steaks using no plates."

An 18-inch mirror blank has been purchased by Harold Simmonds of the Sacramento Valley Astronomical Society in California. How many other ATM's are this ambitious?

Amateurs in the Far East might be interested in *Equatorial*, the new English-language journal of the Ceylon Astronomical Association. The first two issues contain minutes of meetings, planet news, and articles on knife-edge testing of mirrors, double stars for small telescopes, stellar classification, and Earth as seen from the moon. Contact D. S. H. Gunawardene, 31/5 Castle St., Colombo 8, Ceylon.

Attendance records at astronomical activities in Omaha, Nebraska, were broken by the local astronomy club's lunar eclipse party there last August. Three to four thousand people responded to newspaper and radio invitations, but since there were only 10 or so instruments on hand, the lines to each telescope must have averaged several hundred persons! Station KBON interviewed amateurs and their visitors on the spot.

"Spur-of-the-moment" star parties are usually difficult for a club to organize, no one being sure who would be interested. In a recent issue of the Sacramento Valley Astronomical Society's newsletter appears a short form to be filled out by those ready for sudden calls to astronomical observing.

In August, 1960, a telescope making section was formed as part of the Astronomical Society of Southern Africa in Cape Town. J. S. Bondetti reports that, thanks to extensive newspaper publicity, the group now has 58 members; it uses two rooms at the Royal Cape Observatory. Ten members undertook the construction of 6-inch Newtonian reflectors of standard design; their instruments, complete with all-metal mountings, eyepieces, and diagonals, cost only about $50 each. A 12-inch Cassegrainian, to be housed in a fully equipped dome, is in the planning stage.

G. B. C.

Members of the American Association of Variable Star Observers held their 50th anniversary meeting at Harvard Observatory, Cambridge, Massachusetts, on October 12-15, 1961. Photograph by James K. Ufford.

The AAVSO Celebrates Its 50th Anniversary

HARVARD OBSERVATORY once again was host to the American Association of Variable Star Observers, for its 50th anniversary celebration on October 12-15. The Cambridge, Massachusetts, setting was fitting for several reasons: the influence of Harvard astronomers E. C. Pickering and Leon Campbell on AAVSO history, the memorable series of annual fall meetings at the observatory, and the proximity of society headquarters.

At the opening session, Director Margaret W. Mayall reported the activities of the AAVSO in the year ending September 30th. During that period, Reginald P. de Kock, of South Africa, made more observations of variables (5,858) than any other member; next came Cyrus Fernald, Wilton, Maine, and Edward Oravec, Tuckahoe, New York. The over-all total of observations since 1911 was 1,948,707, and the two-millionth brightness estimate will probably be made early next year.

Over 15 papers by members were presented, on subjects ranging from supernovae and a peculiar *S*-type star to meteors and orbiting observatories. Following this, Dr. Dorrit Hoffleit (Maria Mitchell Observatory) conducted a symposium in which four professional astronomers gave talks on modern aspects of variable star study. Harlan J. Smith (Yale) discussed photoelectric photometry; Valfrids Osvalds (Leander McCormick), proper motions of Mira stars; Helen S. Hogg (David Dunlap), variables in clusters; and Cecilia Payne-Gaposchkin (Harvard), evolution of variable stars.

There was a full program of social events. Members went on a tour of the Smithsonian Astrophysical Observatory, and visited Harvard's Agassiz station to see the 61-inch reflector and the 60-foot radio telescope. At a gathering on Friday night, Harlow Shapley spoke on the astronomical highlights of the past half century, a variation on his highlights-of-the-year talks, long a regular feature of AAVSO annual meetings.

The history of the association was the subject of several papers given at the closing session. These recreated the early days when the organization consisted of only a small handful of enthusiastic observers. Special mention was made of G. B. Lacchini in Italy, who joined the AAVSO at its start and has been a leading member ever since.

At the same session, papers were presented by members of the society's solar division. Remarkable lapse-rate motion pictures from the Lockheed Solar Observatory demonstrated flares and fast-moving disturbances of the kind reported in this magazine, March, 1961, page 145.

Officers of the AAVSO for the coming year were announced at the society banquet. Dr. Hoffleit was elected president, with William Cleaver and George Diedrich as vice-presidents. Clinton B. Ford continues as secretary, and Mrs. Mayall as director. After 30 years of service, Percy W. Witherell has retired as treasurer, being replaced by Richard H. Davis. Two new winners of the AAVSO merit award were named, Mr. de Kock for his exceptional observing record, and Mr. Ford for his long service to the society.

Many members came from long distances to the meeting: Leif Robinson and Claude Carpenter from California, Robert Adams from Missouri, the Ralph Buckstaffs from Wisconsin, the Albert Sharplesses from Florida, and a large delegation from Canada.

CHARLES H. GIFFEN
Princeton University
Princeton, N. J.

THIS MONTH'S PROGRAMS

El Paso, Tex. Orion Society, 8 p.m., Texas Western Museum. December 5, Dr. Clyde Tombaugh, New Mexico State University, "Mars as a World."

New Orleans, La.: Pontchartrain Astronomy Society, 8 p.m., Louisiana State University science building. December 1, Bonnie Gonzales, "Possibilities of a Lunar Atmosphere," and Henry J. Folse, Jr., "Theories on the Origin of the Universe."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. December 6, Dr. A. H. Mikesell, U. S. Naval Observatory, "The Stuff of Stars."

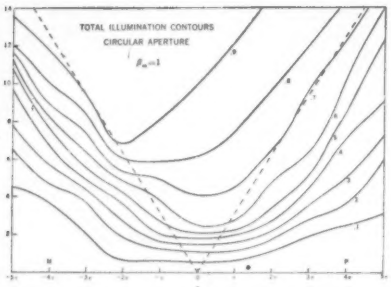
New York, N. Y.: Junior Astronomy Club, 8 p.m., Waverly Building, New York University. December 1, Leif Robinson, "Observing the Moon." December 15, Dr. Harlan J. Smith, Yale University Observatory, "Planetary Radio Astronomy."

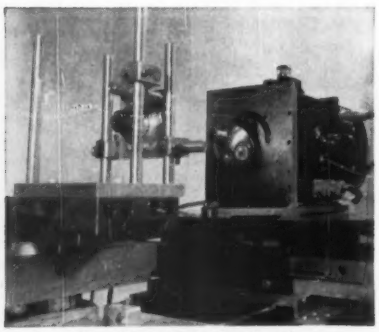
Philadelphia, Pa.: Rittenhouse Astronomical Society, Franklin Institute. December 8, Dr. Su-Shu Huang, Princeton University, "Some Interesting Orbits for Moon Probes."

Pittsburgh, Pa.: Amateur Astronomers Association of Pittsburgh, Allegheny Observatory. December 8, motion picture, How Many Stars?

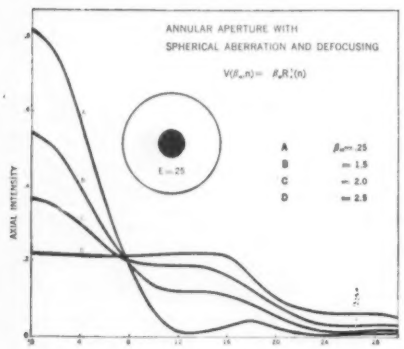
Shreveport, La.: Shreveport Junior Astronomical Society, 7:30 p.m., Centenary College science hall. December 16, Dr. Wallace Herbert, Louisiana Polytechnic Institute, "Stars and Arithmetic."

Optical Craftsman





Sine Wave Analyzing Bench



Knowledge is of two kinds

We know a subject ourselves, or we know where we can find information upon it.
— SAMUEL JOHNSON

Since the beginning of recorded history, man's ability to store and retrieve information has paced his progress. Today man's volume of information is developing at an exponential rate, in thousands of forms and languages. However, lacking the means to store, collect, catalog, and retrieve it quickly and simply — much of this information is useless.

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INDEX to Volume XXII

July to December, 1961

Titles

American Astronomers Report —
Binary Frequencies Among *A*-type Stars, 131
Classification of Galaxies, 129
Polarization of Galactic Radio Noise, 131
Radio Source 3C-48, 131

Astronomers Discuss Project West Ford, 25

Astronomers Meet at Nantucket, 70

Astronomical Notes from Berkeley (see also under Titles, International Astronomical Union meeting of August, 1961) —
Evidence for Intergalactic Absorption, 205
Site Testing, 204
Solar Convection Cells, 204
Spectra of AE Aquarii, 255
Standard Terminology for Meteoric Astronomy, 254
U Geminorum Variable Stars, 204

Astronomy in 1900, *Otto Struve,* 64

Astronomy in Venezuela, *Stuart J. Inglis,* 251

Comet Wilson 1961d, 124; correction, 235

Compact Planetary Groupings, *Jean Meeus,* 320

Construction of a Filar Micrometer, The, *Charles E. Worley,* 140

Convention at Detroit, *Norman C. Dalke,* 136

Convention at Long Beach, *Alan McClure,* 194

E. E. Barnard and Milky Way Photography, *Otto Struve,* 14

Eclipse of the moon of August 25, 1961 (see also under Departments, Observer's Page) —
Lunar Eclipse Roundup, 200

Eclipse of the sun of February 4-5, 1962 —
Weather Prospects for the Eclipse in February, *Edward M. Brooks,* 318

Exciting August, An, 183

Explosions in Nuclei of Galaxies, *Otto Struve,* 248

First Two Decades, The, 247

France's Haute Provence Observatory, *Jean Dufay* and *Charles Fehrenbach,* 4

International Astronomical Union meeting of August, 1961 (see also under Titles, Astronomical Notes from Berkeley) —
IAU Berkeley Assembly, 185
IAU Field Trips and Social Events, 189
IAU Symposium on Galaxies, *John B. Irwin,* 258
IAU Symposium on Visual Double Stars, *Joseph Ashbrook,* 315

Interstellar Medium, The, *Bart J. Bok,* 86

Johann Kepler and the Laws of Planetary Motion, *Rufus Suter,* 22

Measuring Double Stars with a Filar Micrometer, *Charles E. Worley,* 261

Meteor Photography with a Light Amplifier, *Grady T. Hicks,* 142

More About the Earth's Cloud Satellites, 63

News of Four Comets, 311

Occultation Supplement — 1962 Predictions for the United States and Canada, 273

Passage of a Flare Spray Through the Solar Corona, *Frank Q. Orrall* and *Henry J. Smith,* 330

Pictures of the September 30th Aurora, 322

Radio Ursigrams, *Martin H. Potter,* 12

Sidelights on Variable Star Observing, *Clinton B. Ford,* 312

Solar Magnetism and Sunspot Formation, 3

Solar Museum at the Equator, A, *Hazel O'Hara,* 192

Some Massive Binary Stars, *Otto Struve,* 323

Some Russian Radio Telescopes, *G. W. Swenson, Jr.,* and *R. N. Bracewell,* 77

Stellar Radial Velocities and Their Observation, *Otto Struve,* 132

T Tauri Stars and Associated Nebulosities, *Otto Struve,* 197

Ten Years of Solar Eclipses, *Raymond N. Watts, Jr.,* 29

Two Giant Radio Telescopes, 326

Variable Star Spectroscopist, *Margaret W. Mayall,* 127

Visual Observing of Double Stars, *Charles E. Worley,* 73

Authors

Anderson, Christopher M., Jupiter's Red Spot, 210; correction, 290

Archer, Simon, letter, 202

Ashbrook, Joseph, Astronomical Scrapbook, 85, 196, 331
book reviews, 42, 351
IAU Symposium on Visual Double Stars, 315
Observing with a Clinometer, 34

Blair, George A., book review, 225

Bok, Bart J., Interstellar Medium, The, 86

Botham, J. H., Amateur Observatory in the Transvaal, An, 27

Bracewell, R. N., see *Swenson, G. W., Jr.*

Brooks, Edward M., Weather Prospects for the Eclipse in February, 318

C. A. F., see *Federer, Charles A., Jr.*

Canstein, Ruth, book review, 226

Cook, Kelly L., letter, 69

Cox, Robert E., Checking Concentricity of Maksutov Correcting Lenses, 52
Cleaning the Lens of a 12¼-inch Refractor, 106
conductor, Gleanings for ATM's, 47, 106, 166, 232, 294, 359
Eyepieces of Interest to Amateurs, 294
Foucault Light Source from a Flashlight Bulb, A, 170

Crowley, Ariel L., Pineview Observatory, 109

Cullen, P. F., Geelong, Australia, 208

Dakin, Ralph K., Use of a Barlow Lens, The, 362

Dalke, Norman C., Convention at Detroit, 136

Doschek, Antony and *George,* 8-inch "Beavertail" Dall-Kirkham Reflector, An, 47

Dufay, Jean, and *Fehrenbach, Charles,* France's Haute Provence Observatory, 4

Ernst, Bruno, letter, 257
Teaching Observatory in the Netherlands, A, 336

Fay, John V., III, Meteor Shower from Bootes, 94
Federer, Charles A., Jr., book review, 101
Fehrenbach, Charles, see *Dufay, Jean*
Fies, William J., Jr., Observing Venus near Inferior Conjunction, 344
Ford, Clinton B., Sidelights on Variable Star Observing, 312
Fucs, Alexandre, Planetarium in Brazil, 147

G. A. B., see *Blair, George A.*
G. B. C., see *Parker, Gail C.*
Gagan, James W., Stellafane Meeting, 27
27th Annual Stellafane Meeting, The, 208
Giffen, Charles H., AAVSO Celebrates Its 50th Anniversary, The, 337
Gildenberg, Bernard D., letter, 21
Gingerich, Owen, book review, 353
Glenn, William H., Meteors, 54, 114, 238, 302, 367
Sun, Moon, and Planets This Month, The, 55, 115, 175, 239, 303, 367
Gold, Thomas, book review, 100
Gunawardena, D. S. Herschel, letter, 21
Gunn, James E., Celestial Photography with an 8-inch Reflector, 149

Hamilton, Giles E., Mansfield, Ohio, 147
Hernandez, Jose, North-Central Report, 84
Herring, Alika K., book review, 288
Observing the Moon, Hesiodus, 217; Lassell, 33
Hicks, Grady T., Meteor Photography with a Light Amplifier, 142
Houston, Walter Scott, Deep-Sky Wonders, 35, 97, 154, 213, 281, 348
Howard, William E., book review, 41

Inglis, Stuart J., Astronomy in Venezuela, 251
Irwin, John B., book review, 157
IAU Symposium on Galaxies, 258

J. A., see *Ashbrook, Joseph*
Jenzano, A. F., book review, 40

Katherman, Mrs. Ruth P., York, Pennsylvania, 147
King, Ivan R., book review, 41
Knab, Oscar R., Improved 4¼-inch Unobstructed Oblique Reflector, An, 232
Konstanzer, Gordon, Pole Finder for Portable Telescopes, A, 168
Krumm, Walter J., book review, 286

Lipphard, Mrs. Virginia C., Louisville's Star Lane Observatory, 269
Lucas, Mrs. Diane, Prize-Winning Gregory-Maksutov Telescope, A, 359
Lumley, Edward, Figuring a Paraboloid with the Ronchi Test, 298

Mathews, Robert T., book review, 99
Mayall, Margaret W., Variable Star Spectroscopist, 127
McClure, Alan, Convention at Long Beach, 194
McCuskey, S. W., book review, 353
Meeus, Jean, Compact Planetary Groupings, 320
Melin, Marshall, Observing the Satellites, 23, 81, 143, 206, 264, 332

Naef, Robert A., book review, 158
Nielsen, Axel V., letter, 69
Norton, Wayne L., Simple Aluminum Camera Support, A, 166

O'Hara, Hazel, Solar Museum at the Equator, A, 192
Ordway, Frederick I., III, book review, 225
Orrall, Frank Q., and *Smith, Henry J.,* Passage of a Flare Spray Through the Solar Corona, 330

Page, Thornton, book review, 39; correction, 161
Parker, Gail C., Amateur Briefs, 28, 84, 147, 209, 269, 336
Petersen, Norman D., Photographing the Perseids, 282
Potter, Martin H., Radio Ursigrams, 12
Price, Robert C., Occultation of Aldebaran, 347

Quester, Wolfgang, Variable Star Society in Germany, 27

R. E. C., see *Cox, Robert E.*
R. N. W., see *Watts, Raymond N., Jr.*
Raddatz, Harold G., Chicago Amateur's Garage-Top Palomar, A, 110
Rippen, George W., Aurora Predictions Confirmed, 154
Rohr, Hans, letter, 202

Schultz, Sherman W., Jr., Active Amateur in St. Paul, An, 26
Searcy, William P., III, Amateur's Sky Atlas, An, 214
Selby, Horace H., book review, 159
Shapley, Harlow, book review, 158
Shawcross, William E., Questions from the S+T Mailbag, 13, 85, 131, 209
Shinsel, Ruth, letter, 21
Shklovsky, I. S., letter, 21
Smith, Burris, Face in Nebulosity, A, 147
Smith, Henry J., see *Orrall, Frank Q.*
Stairs, Lt. Col. J. A., Messier Objects for Fall Viewing, 152
Messier Objects for Winter Viewing, 345
Steuber, Jerome, and *Tooley, Russ,* High School Observatory and Weather Station, A, 146
Struve, Otto, Astronomy in 1900, 64
E. E. Barnard and Milky Way Photography, 14
Explosions in Nuclei of Galaxies, 248
Some Massive Binary Stars, 323
Stellar Radial Velocities and Their Observation, 132
T Tauri Stars and Associated Nebulosities, 197
Suter, Rufus, Johann Kepler and the Laws of Planetary Motion, 22
Swenson, G. W., Jr., and *Bracewell, R. N.,* Some Russian Radio Telescopes, 77

Tooley, Russ, see *Steuber, Jerome*
Turner, George P., Tennessee Amateurs Produce Astronomical Exhibit, 209

Volcheck, Emil, AL Regional Convention, 270
Volk, Victor F., Westchester Astronomers League, 27

W. E. S., see *Shawcross, William E.*
Warner, Brian, Rilles in Palus Epidemiarum, 346
Watts, Raymond N., Jr., Lunar Eclipse in August, 92
Ten Years of Solar Eclipses, 29
Wentworth, Jimmy, Iowa Star Party, 270
Wilson, A. Stewart, letter, 123
Worley, Charles E., Construction of a Filar Micrometer, The, 140
Measuring Double Stars with a Filar Micrometer, 261
Visual Observing of Double Stars, 73
Wyatt, Stanley P., book review, 285

Departments and Features

Amateur Astronomers —

AAVSO Fall Meeting, 147; AAVSO Celebrates Its 50th Anniversary, The, 337
Active Amateur in St. Paul, An, 26
Amateur Briefs, 28, 84, 147, 209, 269, 336
Amateur Observatory in the Transvaal, An, 27
Boise, Idaho, 209
Clifton, New Jersey, 270
Face in Nebulosity, A, 147
Geelong, Australia, 208
High School Observatory and Weather Station, A, 146
Iowa Star Party, 270
Lakeland, Florida, 27
Louisville's Star Lane Observatory, 269
Mansfield, Ohio, 147
Middle East Convention, 26; AL Regional Convention, 270
Mid-States Convention, 84
North-Central Report, 84
Planetarium in Brazil, 147
Report from Rochester, 27
Society Listing, 27
South Shore Meeting, 84
Stellafane Meeting, 27; 27th Annual Stellafane Meeting, The, 208
Teaching Observatory in the Netherlands, A, 336
Tennessee Amateurs Produce Astronomical Exhibit, 209
This Month's Programs and Conventions, 27, 84, 147, 209, 270, 337
Variable Star Society in Germany, 27
Westchester Astronomers League, 27
York, Pennsylvania, 147

Astronomical Scrapbook —

Beginnings of the Space Age, 85
Companion of Rigel, The, 196
Great September Comet of 1882, The, 331

Books and the Sky —

Astronomie, Joachim Herrmann, 158
Atoms to Galaxies, James Stokley, 101
Captured Stars, Heinz Letsch, 40
Changing Views of the Universe, Colin A. Ronan, 225
Galaxies, Harlow Shapley, 285
Handbuch für Sternfreunde, Günter Dietmar Roth, editor, 42
Methods of Celestial Mechanics, Dirk Brouwer and Gerald M. Clemence, editors, 353
Milky Way Galaxy, The, Ben Bova, 226
Physical Science, Donald S. Allen and Richard J. Ordway, 99
Planets, Stars, and Galaxies, Stuart J. Inglis, 39; correction, 161
Radio Astronomy, F. Graham Smith, 41
Rival Theories of Cosmology, H. Bondi, W. B. Bonnor, R. A. Lyttleton, and G. J. Whitrow, 41
Rotation of the Earth, The, Walter H. Munk and Gordon J. F. MacDonald, 100
Science in Space, Lloyd V. Berkner and Hugh Odishaw, editors, 225
Stellar Atmospheres, Jesse L. Greenstein, editor, 353
Structure of the Moon's Surface, Gilbert Fielder, 351
Surface of the Moon, V. A. Firsoff, 288
Technique of Optical Instrument Design, The, R. J. Bracey, 159
Telescope and the World of Astronomy, The, Marvin F. Riemer, 286
Telescopes, Gerard P. Kuiper and Barbara M. Middlehurst, editors, 157
Universe at Large, The, Hermann Bondi, 158

Celestial Calendar —

Aldebaran Occultation, 114
Early-Morning Occultation of Aldebaran, An, 54
Favorable Occultation of Aldebaran, A, 174
Jupiter Without Satellites, 54
Jupiter's Satellites, 55, 115, 175, 239, 303
Meteors, 54, 114, 238, 302, 367
Minima of Algol, 54, 114, 174, 238, 302, 366
Minor Planet Predictions, 54, 114, 174, 238, 303, 366
Moon Phases and Distances, 54, 114, 174, 239, 302, 366
Occultation of Aldebaran and Regulus, 302
Sun, Moon, and Planets This Month, The, 55, 115, 175, 239, 303, 367
Variable Star Maxima, 55, 114, 174, 238, 302, 366
Variable stars: X Ophiuchi, 54; Eclipsing Variable OO Aquilae, The, 114 (correction, 235); RT Cygni, 174; U Vulpeculae, 238; SW Andromedae — A Cluster-Type Variable, 302; V Cassiopeiae, 366

Feature pictures —

Adlai E. Stevenson addressing the International Astronomical Union, 184
Yerkes Observatory 40-inch refractor, 128

Front-cover photographs —

Australia's 210-foot radio telescope, 61
Bright July comet, 121
Haute Provence 76-inch reflector, 1
Planetarium in Venezuela, 245
September northern lights, 309
Sundial on the equator, 181

Getting Acquainted with Astronomy —

Jupiter's Satellites, 19
Planets, The, Saturn, I, 138; II, 256 (correction, 355)

Gleanings for ATM's —

Checking Concentricity of Maksutov Correcting Lenses, 52
Chicago Amateur's Garage-Top Palomar, A, 110
Cleaning the Lens of a 12¼-inch Refractor, 106
8-inch "Beavertail" Dall-Kirkham Reflector, An, 47
Eyepieces of Interest to Amateurs, 294
Figuring a Paraboloid with the Ronchi Test, 298
Foucault Light Source from a Flashlight Bulb, A, 170
Gleanings notes, 51, 235, 363
Help for Beginners, 110
Improved 4¼-inch Unobstructed Oblique Reflector, An, 232
Pineview Observatory, 109
Pole Finder for Portable Telescopes, A, 168
Prize-Winning Gregory-Maksutov Telescope, A, 359
Simple Aluminum Camera Support, A, 166
Use of a Barlow Lens, The, 362

Here and There with Amateurs, 219

In the Current Journals, 10, 72, 126, 203, 267, 328

Letters, 21, 69, 123, 202, 257

New Books Received, 43, 102, 161, 228, 290, 355

News Notes —

Aniara, 126
Atlas of Star Clusters, 203
Bird Migration Studies, 72
California Fireball, 72
Changes in Atmospheric Drag, 253
Changing Orbit of Comet Oterma, 72
Chemical Analysis of the Lunar Surface, 267
Cloud Satellite of the Earth, 328
Comet Humason, 202
Davis, George A., Jr., Dies, 9
829 Comet Orbits, 329
42 Comae Berenices, 203
Interference Coatings on Aluminized Mirrors, 10
IAU Meeting, 72
Layered Surface of the Moon, 203
Major Solar Flare, 268
Man-in-Space Exhibition in New York City, 328
Micrometeorite Layer, 126
Naval Observatory Library, 11
New Harvard Radio Telescope, 126
New Instrument at Fels Planetarium, 196
New Natural Satellites of the Earth? 10
1961 Solar Eclipse Reports, 321
Observing Time on Kitt Peak, 25
Origin of Planetary Material, 267
Positions of Features on Mars, 126
Shapes of Lunar Craters, 10
Teaching the Earth Sciences, 267
Temperatures on Mercury, 10
Unnumbered Minor Planets, 203
Unusual New Eclipsing Star, 328
Young, Anne S., Dies, 314

Observer's Page —

Amateur's Sky Atlas, An, 214
August Auroras, 214
Aurora Predictions Confirmed, 154
Celestial Photography with an 8-inch Reflector, 149
Deep-Sky Wonders, 35, 97, 154, 213, 281, 348
Eclipse of the moon of August 25, 1961 (see also under Titles): Lunar Eclipse in August, 92
Jupiter's Red Spot, 210; correction, 290
Mars-Uranus Conjunction, 85
Messier Objects for Fall Viewing, 152
Messier Objects for Winter Viewing, 345
Meteor Shower from Bootes, 94
Mutual Phenomena of Jupiter's Satellites, 32
Notes on Comet Wilson, 212
Observations of Delta Librae, 213
Observations of RZ Cassiopeiae Wanted, 95
Observations of Saturn and the Moon, 94
Observations of the Perseids in August, 215; Photographing the Perseids, 282
Observing the Moon, Hesiodus, 217; Lassell, 33
Observing Venus near Inferior Conjunction, 344
Observing with a Clinometer, 34
Occultation of Aldebaran, 347
Occultation of Porrima by the Moon, 93
Rilles in Palus Epidemiarum, 346
Sunspot Numbers, 34, 95, 155, 217, 283, 345
SZ Herculis Predictions, 32
Transits of Jupiter's Red Spot, 155
Two Planets and the Moon, 283
UV Leonis, 346
Widespread Northern Lights on September 30th, 271

Observing the Satellites —

Another Weather Satellite, 143
Discoverer XXV, 81
Discoverer XXVI, 146
Far-Swinging Explorer XII, 207
Forty Fragments, 143
Fourth Year of the Space Age, 333
Man in Space, 23
Manned Spaceflight, June, 1961; correction, 25
Midas III, 145
Midas IV and Project West Ford, 333

New Ground-Support Facilities, 264
Notes on Discoverers, 332
Ranger I, 208
Ranger Project, The, 82
Satellite for Gamma-Ray Astronomy, A, June, 1961; correction, 25
Short-Lived Explorer XIII, 206
Three Discoverer Satellites, 267
Transit IV-A, 81
Unmanned Mercury Orbit, 266
Vostok Flight Records, 25
Vostok II, 206

Planetarium Notes, 163

Questions from the S+T Mailbag, 13, 85, 131, 209, 263, 325

Southern Stars, 116, 240, 368

Stars for . . . (current month), 57, 117, 177, 241, 305, 369

Selected Topics and Celestial Objects

This listing is not intended to be exhaustive, and does not supplant the other parts of the index. For example, material from such regular features as Observing the Satellites ordinarily appears only under the heading Departments and Features.

Amateur astronomers: meetings — AAVSO, 337; Astronomical League, 27, 84, 136, 270; Massachusetts South Shore, 84; Stellafane, 208; Western Amateur Astronomers, 194; societies — Australia, 208; Boise, Idaho, 209; Ceylon, 21, 336; Clifton, N. J., 270; El Paso, Tex., 269; Germany, 27; Lakeland, Fla., 27; Mansfield, Ohio, 147; South Africa, 336; Switzerland, 84; Westchester Co., N. Y., 27; York, Pa., 147; star party, 270

Asteroids: orbits, 203

Auroras: 21, 154, 214; September 30th, 271, 311, 322

Bird migration studies: 72

Clinometer: 24

Clusters: atlas of, 203; globular — M4, 35; M10, M12, M14, 97; M16, 152; M30, 214; M72, 154; M80, 35; NGC 6144, 35; NGC 6366, NGC 6517, NGC 6535, NGC 6539, 97; NGC 6541, 35; NGC 7006, NGC 7492, 214; open — Pleiades, 152

Comets: orbits, 329; 1882 II, 331; Humason, 202, 329; Oterma, 72; Schwassmann-Wachmann 1, 329; Seki, 311; Wilson, 123, 124, 212, 329

Double stars: *A*-type, 131; IAU symposium, 315; massive, 323; observing, 73, 140, 261; Beta Lyrae, 324; 42 Comae Berenices, 203; Plaskett's star, 324; Rigel, 196; Zeta Aquarii, 281

Earth: atmosphere, 253; new natural satellites, 10, 63, 328; sciences, 253

Eclipses: 10 years of solar, 29; February 15th solar, 321; August 25th lunar, 92, 200; February 4-5, 1962, solar, 318, 320

Education: earth sciences, 267; solar museum, 192; space exhibit, 328

Galaxies: classification, 129; IAU symposium, 258; nuclear explosions in, 248; M83, 345; NGC 584, NGC 596, NGC 615, NGC 636, NGC 720, NGC 779, 348; NGC 7479, 214

History: astronomy in 1900, 64; E. E. Barnard, 14; companion of Rigel, 196; great comet of 1882, 331; Johann Kepler, 22; SKY AND TELESCOPE, 247; space-age beginnings, 85; supernova S Andromedae, 69; telescope inventor, 257

Intergalactic absorption: 205

Interstellar matter: 86

Jupiter: 320; red spot, 155, 210; satellites, 19, 32, 54

Mars: 320; mapping, 126

Mercury: 320; temperatures, 10

Messier objects: fall, 152; winter, 345; M4, 35; M10, M12, M14, 97; M16, M17, 152; M30, 214; M42, M51, 152; M72, 154; M80, 35; M83, 345

Meteors: California fireball, 72; from Bootes, 94; Perseids, 215, 282; photography, 142; terminology, 254

Micrometeorites: 126

Milky Way: 86; photography, 14

Moon: 320; and Saturn, 94; crater shapes, 10; features — Hesiodus, 217, Lassell, 33; planetary configurations, 283, 320; rilles in Palus Epidemiarum, 346; surface, 203, 267; see also Eclipses

Nebulae: diffuse — Horsehead, M17, M51, NGC 6992, 152; Rosette, 149; planetary — NGC 246, 348; NGC 7009, 154

Observatories: Caracas, 251; Haute Provence, 4; amateur, 26, 27, 109, 110, 146, 269, 336

Occultations: Aldebaran, 54, 114, 174, 302, 347; Porrima, 93; Regulus, 302

Opera: *Aniara,* 126

Optics: Foucault light source, 170; interference coatings, 10; lens cleaning, 106; Ronchi test, 298

Personal notes: G. A. Davis, Jr., 9; P. W. Merrill, 127; Anne S. Young, 314

Photography: amateur, 149, 347; comet, 331; meteor, 142; Milky Way, 14

Planetariums: Annapolis, Md., 269; Caracas, 251; Philadelphia, Pa., 196; Rio de Janeiro, 147

Planets: close groupings, 320; Mars-Uranus conjunction, 93; Moon, Venus, and Mercury, 283

Professional astronomers: meetings — AAS, 70; IAU, 185, 189, 258, 315

Radio astronomy: galactic studies, 131, 260; sources — Cygnus A, 21; Milky Way, 86; 3C-48, 131

Radio telescopes: Harvard, 126; Puerto Rico, 326; Russian, 77; Stanford, 326

Saturn: 138, 256, 320; and Moon, 94; rings and satellites, 320, 355

Site testing: 204

Solar museum in Ecuador: 192

Solar system: origin, 267

Spectrum: AE Aquarii, 255

Stars: radial velocities, 132

Sun: 320; convection cells, 204; corona, 330; flares, 268, 330; magnetism, 3; radio Ursigrams, 12; spots, 3; see also Eclipses

Supernova: S Andromedae, 69

Telescope accessories: Barlow lens, 362; camera support, 166; eyepieces, 294; filar micrometer, 140; pole finder, 168

Telescopes: Dall-Kirkham, 47; inventor, 257; Maksutov, 52, 359; oblique reflector, 232

Variable stars: observing, 312; S Andromedae, 69; SW Andromedae, 302; AE Aquarii, 255; OO Aquilae, 114, 235; RZ Cassiopeiae, 95; V Cassiopeiae, 366; RT Cygni, 174; U Geminorum, 204; SZ Herculis, 32; UV Leonis, 346; Delta Librae, 213; X Ophiuchi, 54; T Tauri type, 197; U Vulpeculae, 238; HBV 242, 328

Venus: 320; daytime observing, 344

West Ford, project: 25, 333

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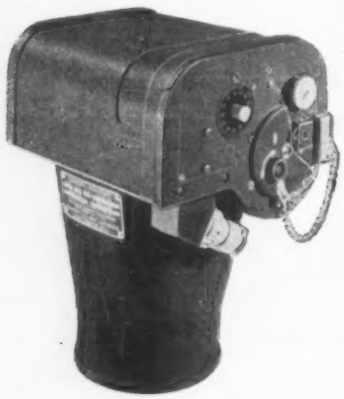

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OBSERVER'S PAGE

Universal time (UT) is used unless otherwise noted.

Observing Venus near Inferior Conjunction

LAST APRIL, as Venus was passing inferior conjunction, I decided to see how close to the sun the planet could be observed. The severe hazard to vision of accidentally sighting the sun with my 6-inch reflector ruled out simply scanning the sky in search of the planet. How then could I locate Venus without setting circles?

The solution proved to be simple and accurate, allowing me to observe within a few degrees of the sun with no danger. As shown in the picture, two brackets were attached to the outside of the telescope tube near its ends. Screens made of white cardboard were clipped to the brackets with paper clamps and placed so that one screen shaded the other when the telescope was aimed toward the sun. A small hole, about 3/16 inch, in the front screen cast a spot of light onto the rear cardboard, which was then used as a plotting board. When the place of the sun was marked, the relation between the field of view and the sun's location could be seen at a glance.

After marking the sun's position on the plotting board, the telescope was moved until the spot of light shifted a distance corresponding to the difference in position between the sun and Venus. This process brought the planet into the field of a low-power eyepiece and obviated any sweeping so close to the sun.

To determine the distance on the plotting board corresponding to the differences in right ascension and declination, several steps were necessary. First, the co-ordinates of the two objects for the date of observation were found in the *American Ephemeris and Nautical Almanac*. Since my low-power eyepiece covers a field of about 1½ degrees, I found that it was not necessary to interpolate for the time of observation, so I simply used the ephemeris positions given for zero hours.

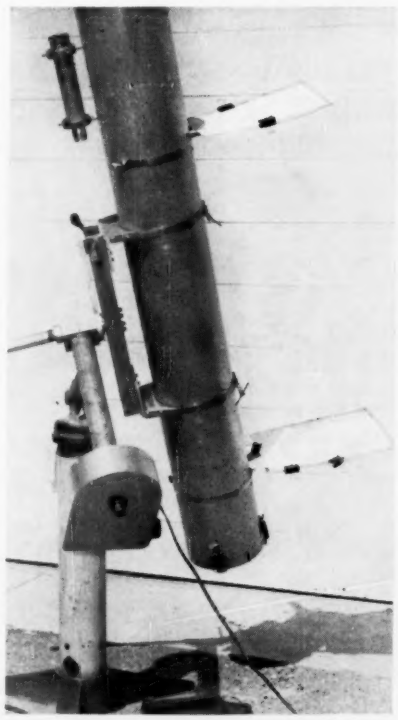
The difference in right ascension of the sun and Venus, in time units, was converted to degrees by means of the table in the back of the ephemeris. An accurate conversion requires a further step — multiplication by the cosine of the declination — but because the sun is always less than 24 degrees from the equator, the cosine is between 0.9 and one, and I decided to neglect this step, too.

To find the distance on the plotting board that represents the difference in right ascension or declination, the tangent of the angular difference is multiplied by the distance between the screens.

With the telescope pointed directly at the sun, the position of the bright spot was marked and labeled *Sun*. The telescope was then moved in right ascension, care being taken not to change the declination setting. The resulting motion of the light spot on the plotting board defined the direction along which the right ascension difference was measured. From the end point of this plot, the declination difference was laid out at right angles. The end point of the perpendicular was marked *Venus*, and when the telescope was set so that the spot of light fell there, the planet was in the field of view. The direction in which to measure along the two lines depends upon whether the planet is east or west, north or south of the sun.

Using this system, I was able to observe Venus on four consecutive days starting April 7th, followed by a single observation on the 15th. Each session began about noon and continued for one to four hours. At closest approach, on the 9th, Venus was only about eight degrees from the sun. Seeing the planet was not difficult under these conditions, and I believe this technique could be used to within five degrees of the sun. Venus appeared as a very narrow crescent convex toward the sun. A magnification of 40 was used for initial location, followed by 80x once the planet was centered in the field.

My observations were made with an equatorially mounted telescope, but the method can be used with an altazimuth.



The Venus-locating screens attached to the author's 6-inch reflector, which has a driving motor at the south end of the polar axis. Photograph by James Green, Redwood City, California.

In the latter case, the direction of right ascension is found by letting the spot of sunlight trail across the plotting board, while the telescope is stationary. With portable equatorials, this procedure saves aligning the mounting.

It is well to use extreme caution when observing so close to the sun. Never under any circumstances put the eye to the eyepiece when there is any chance that the sun is in the field, for even the shortest look means damage that is instantaneous and perhaps permanent. My 6-inch will set fire to newspaper at the exit pupil of my 1¼-inch Erfle eyepiece in less than 20 seconds. If scanning is necessary, always move away from the position of the sun.

WILLIAM J. FIES, JR.
2795 Ohio Ave.
Redwood City, Calif.

MESSIER OBJECTS FOR WINTER VIEWING

THE final installment of the list of Messier nebulae and clusters compiled by the Messier Club of the Royal Astronomical Society of Canada's Ottawa Centre is given here. Objects on view during the other seasons were tabulated in the April, June, and September, 1961, issues on pages 219, 344, and 152, respectively.

Two well-known open clusters among those listed for winter are the Pleiades, M45, and Praesepe, M44 — old friends to many an amateur observer. Some of the most spectacular diffuse nebulae are found in the Orion region, crossing the meridian about midnight in December. M42 is the Great nebula and M43 is the northeast section of it.

Although only a featureless glow when viewed in amateur telescopes, the Crab nebula, M1, becomes a complex of nebulosity in photographs made with great reflectors. It is the remnant of a supernova that exploded more than 900 years ago.

Symbols used for type of object are: C, open cluster; D, diffuse nebula; G, globular cluster; P, planetary nebula. The co-ordinates are for 1950, and the magnitudes are approximate visual values.

M	Type	R. A. h m	Dec. ° ′	Mag.	Size ′
AURIGA					
38	C	5 25	+35 48	7	18
36	C	5 33	+34 06	6	16
37	C	5 49	+32 32	6	24
TAURUS					
45	C	3 45	+23 57		120
1	P	5 32	+21 59	10	6 × 4
GEMINI					
35	C	6 06	+24 21	6	29
CANCER					
44	C	8 37	+20 10		90
67	C	8 49	+12 00	7	18
ORION					
42	D	5 33	−05 25		66 × 60
43	D	5 33	−05 18		
78	D	5 44	+00 02		8 × 6
MONOCEROS					
50	C	7 01	−08 16	6	16
LEPUS					
79	G	5 22	−24 34	8	8
CANIS MAJOR					
41	C	6 45	−20 41	6	32
PUPPIS					
46	C	7 40	−14 42	9	27
93	C	7 43	−23 45	6	18

LT. COL. J. A. STAIRS
23 Dunvegan Rd.
Ottawa 2, Ont., Canada

SUNSPOT NUMBERS

The following American sunspot numbers for September have been derived by Dr. Sarah J. Hill, Whitin Observatory, Wellesley College, from AAVSO Solar Division observations.

September 1, 36; **2,** 41; **3,** 41; **4,** 40; **5,** 35; **6,** 32; **7,** 31; **8,** 26; **9,** 41; **10,** 40; **11,** 43; **12,** 44; **13,** 67; **14,** 105; **15,** 105; **16,** 95; **17,** 62; **18,** 48; **19,** 50; **20,** 43; **21,** 39; **22,** 34; **23,** 39; **24,** 57; **25,** 60; **26,** 64; **27,** 65; **28,** 65; **29,** 50; **30,** 44. Mean for September, 51.4.

Below are provisional mean relative sunspot numbers for October by Dr. M. Waldmeier, director of Zurich Observatory, from observations there and at its stations in Locarno and Arosa.

October 1, 45; **2,** 47; **3,** 53; **4,** 50; **5,** 46; **6,** 42; **7,** 40; **8,** 46; **9,** 47; **10,** 53; **11,** 58; **12,** 76; **13,** 47; **14,** 44; **15,** 53; **16,** 46; **17,** 39; **18,** 39; **19,** 46; **20,** 38; **21,** 47; **22,** 33; **23,** 16; **24,** 17; **25,** 7; **26,** 13; **27,** 6; **28,** 7; **29,** 9; **30,** 9; **31,** 8. Mean for October, 36.4.

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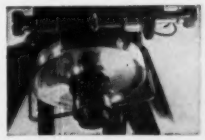

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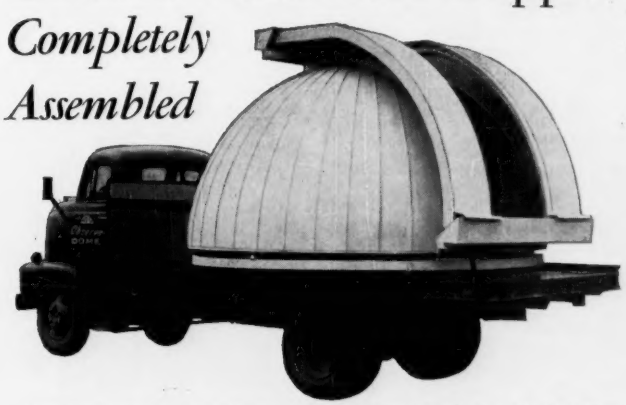

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Rilles in Palus Epidemiarum

Although lunar rilles mainly follow the edges of larger maria, in smaller ones they can occur centrally. One of the moon's most densely packed rille areas is Palus Epidemiarum, a small dark plain close to the southeast corner of Mare Nubium. The most prominent object on this plain is Ramsden, a crater 26 kilometers in diameter.

On December 28, 1960, I observed Palus Epidemiarum with an 18-inch refractor at 520x, and made the accompanying sketch, on which the rilles are overemphasized. South is up, west to left.

These long furrows form a highly complex system with many intersections. Just west of Ramsden are several foci with no conspicuous craters at the points of intersection. The hillock southeast of Ramsden has rilles emanating from it. Other examples of such rille foci are scattered over the moon's surface; for example, rilles run outward from the large craters Sabine and Ritter (Sky and Telescope, November, 1960, page 286).

Many of the rilles had interior shadows, and several landslips or short central ridges were noted. A prominent central ridge was seen in the wide rille extending north from Ramsden. In addition, I saw a row of craterlets along a rille near Campanus, which is the large crater bisected by the lower edge of the sketch. The furrow coming in from the left edge is the easternmost extension of the great Hesiodus rille; as I could detect no interior shadow, it must be very shallow indeed.

Brian Warner's drawing of rilles in the moon's Palus Epidemiarum area.

Two summit pits were found on mountain masses, one north and one west of Ramsden. These are delicate features, to be seen only in large telescopes. The small crater lying on a rille near the center of the sketch is Marth. It has a complete concentric inner ring, whose eastern part was well seen. Marth also seems to be a rille focus.

BRIAN WARNER
University of London Observatory
Mill Hill Park
London N.W. 7, England

UV Leonis

On page 182 of Sky and Telescope for March, 1961, a finder chart and other observing information were given for the eclipsing variable star UV Leonis. Hector Ayala, of Ciudad Juarez, Mexico, has reported brightness estimates of this variable from April to June, 1961, from which nine times of minimum have been deduced, by means of the tracing-paper method described in the February, 1957, issue, page 190.

Listed here are the observed times of minimum, in the form of heliocentric Julian dates:

2,437,401.676	2,437,427.757
2,437,406.768	2,437,428.668
2,437,407.675	2,437,440.665
2,437,410.666	2,437,467.659
2,437,416.675	

Mr. Ayala made an average of 10 estimates during each minimum, the actual numbers ranging from seven to 14.

The observed times can be compared with predictions from the formula for UV Leonis that is given in the 1958 Moscow *General Catalogue of Variable Stars*. On the average, the observed minima occurred 0.019 day earlier than predicted, the mean error of this difference being ±0.003 day.

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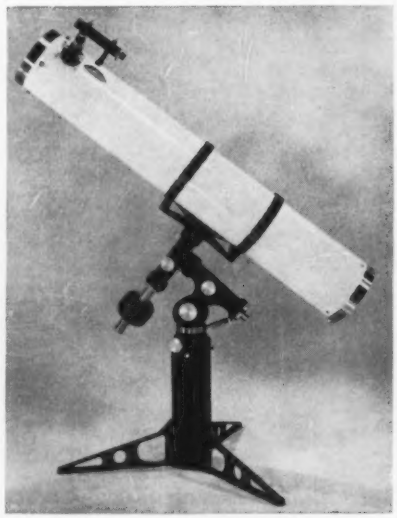

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OCCULTATION OF ALDEBARAN

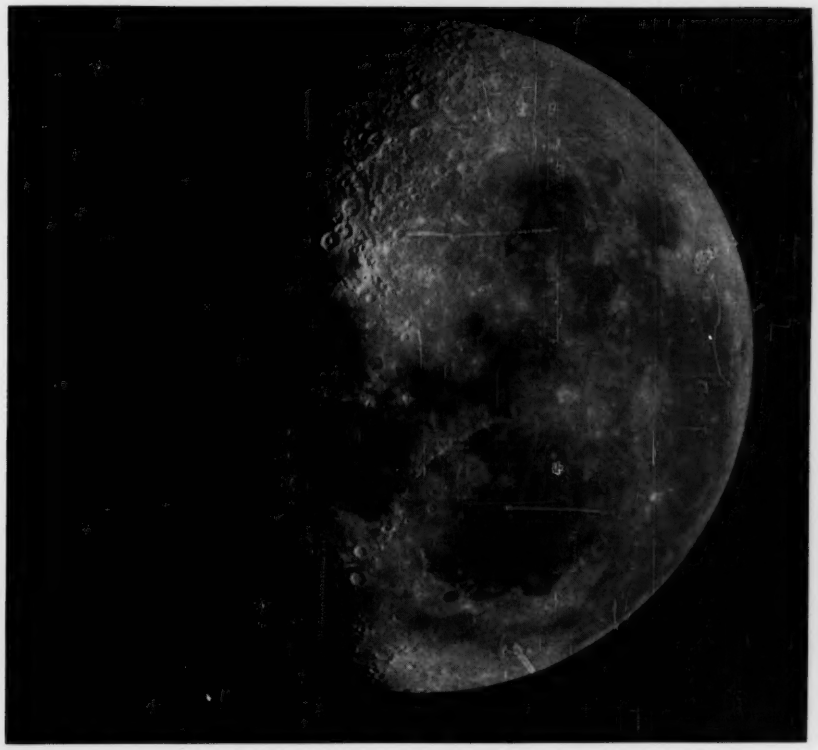
HAVING TRIED astrophotography for about a year, I decided to observe the September occultation of Aldebaran. It is a challenge to capture the moon's limb and terminator, as well as the star, clearly on film.

I used my homemade 6-inch f/8 reflector, driven at about the sidereal rate for these pictures, which are part of a sequence of nine photographs. A 30-mm. eyepiece was used to project the moon's image to $2\frac{1}{2}$ inches in diameter. All exposures were $\frac{1}{5}$ second, on Super Panchro-Press $3\frac{1}{4}$-by-$4\frac{1}{4}$-inch sheet film. For better rendition in the enlargements, I used darkroom dodging techniques.

All times given are approximate, as I have no receiver for radio time signals.

ROBERT C. PRICE
5315 Charlottesville Rd.
Springfield, Va.

The moon approaching Aldebaran on September 29th, photographed by Robert C. Price at (top to bottom) 1:52, 1:56, 1:58, and 1:59 a.m. Eastern daylight time. The star's image, centered in each case, was distorted by poor seeing conditions. Another occultation of Aldebaran will occur this December 20th for observers in the northwestern United States and western Canada.



The 1st-magnitude star Aldebaran is seen near the left margin of this picture, just after its emergence from behind the 19-day-old moon's dark limb. Seeing had improved considerably for the pictures Mr. Price took after emersion, this one at about 3:12 a.m. EDT, September 29th.

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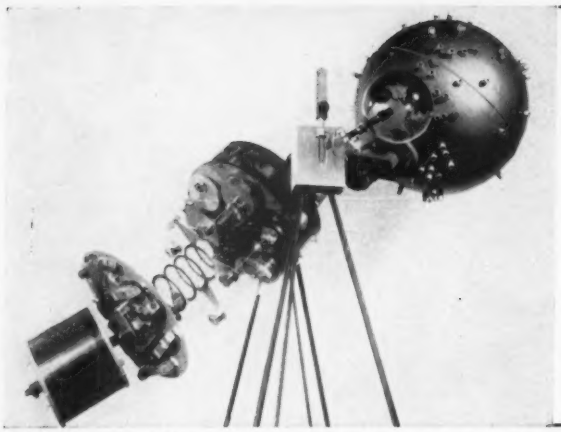

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IN LATE FALL and early winter skies, when the Great Square of Pegasus has crossed the meridian, the amateur observer must hunt for this month's quarry. To the naked eye, Cetus is an especially barren region. Most sky-gazers can pick out little more than the whale's polygonal head or glance at the spot where Mira ranges from 10th to 2nd magnitude.

Although the stellar background is thin in a telescope, galaxies abound and the deep-sky observer may find an occasional planetary nebula. Some are plotted in Norton's *Star Atlas*, but many more are to be found in the Skalnate Pleso atlas.

About 6° north of Beta Ceti is NGC 246, at right ascension $0^h\ 44^m.6$, declination $-12°\ 09'$ (1950 co-ordinates). Measuring 4′ by 3′.5, this planetary is about the size of the Owl nebula, and has a low surface brightness. The *Atlas Coeli Catalogue* lists its magnitude as 8.5, but this is misleading, and I suspect that few amateurs have seen NGC 246.

With rather indifferent Connecticut skies I was just able to detect it in a 6-inch refractor, although I knew exactly what to look for. There are several stars scattered in front of it, and one must ignore them. Lack of any central condensation makes this object still more difficult. But it was quite plainly visible through the 20-inch refractor at Van Vleck Observatory here in Middletown. I would welcome post cards describing other amateurs' observations of NGC 246.

Farther east, at $1^h\ 28^m.8$, $-7°\ 07'$, lies the well-known galaxy NGC 584. Labeled 100[1] in Norton's, it has a visual magnitude of 11. It is 2′ by 1′.2 and makes a small but pretty spindle in the dim skies of Cetus. In his *Cycle of Celestial Objects*, Admiral Smyth mentions that in the same field there is a "neat double star, the components of which are of the 9th and 11th magnitudes."

The Skalnate Pleso atlas shows a line of three galaxies east and south of NGC 584. In order of increasing right ascension they are NGC 596, 615, and 636. The first, an elliptical, is the smallest, only 0′.6 by 0′.5, with a visual magnitude of $11\frac{1}{2}$. NGC 615 is the largest of the trio, 2′.7 by 0′.8, and is an Sc spiral with about the same brightness as NGC 596. The last is another, somewhat fainter elliptical, 0′.7 in diameter.

An easier object is NGC 779, 101[1] in Norton's. It is a barred spiral located at $1^h\ 57^m.2$, $-6°\ 12'$ and measuring 3′ by 0′.5. The catalogued visual magnitude of 11.3 may be too faint, as this galaxy is well seen in a 3-inch telescope.

Some 8° south and slightly west is NGC 720. This is a slightly smaller spiral than NGC 584, 1′.3 by 0′.7, but shows up well under powers of about 100. Its listed magnitude of $10\frac{1}{2}$ seems about right.

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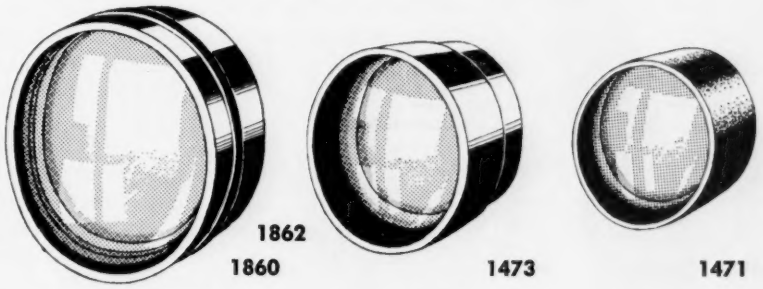

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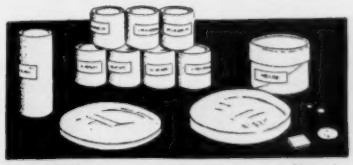

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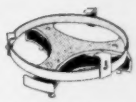

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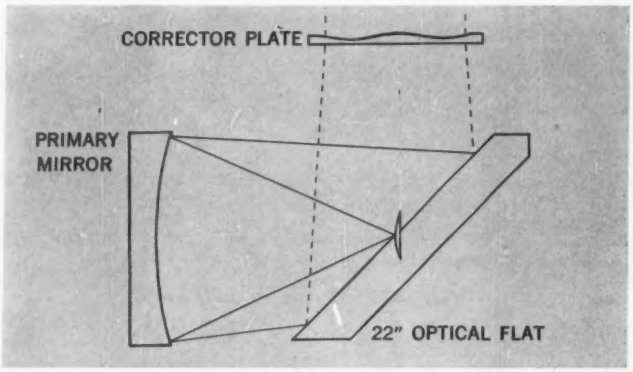

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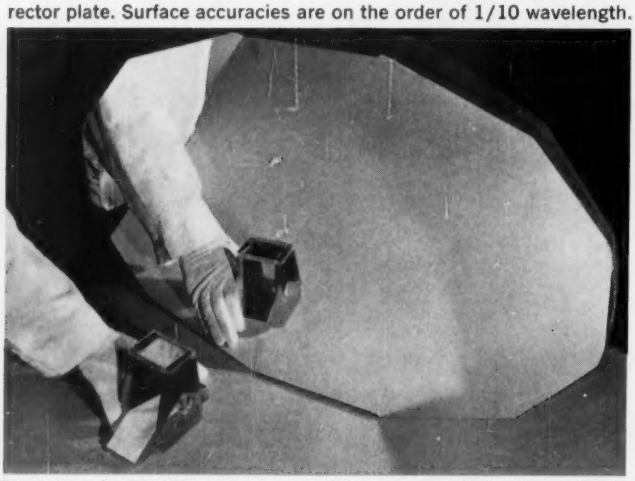

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BOOKS AND THE SKY

STRUCTURE OF THE MOON'S SURFACE

Gilbert Fielder. Pergamon Press, New York, 1961. 266 pages. $7.50.

FOR SOME YEARS, the list of the 10 most wanted but still unwritten books in astronomy has included a comprehensive treatise on the moon — an up-to-date summary of facts and interpretations, on an advanced level. To be sure, there are many popular and semipopular works, some of them excellent, as well as Baedeker-type guidebooks for the amateur observer. But there has been no modern professional monograph. For detailed information on, say, the moon's physical libration or the surface dust layer, one has had to search through widely scattered periodicals.

The need for a synthesis has grown much more pressing in the last few years, as lunar studies have gained in popularity. It is increasingly difficult for professional and amateur astronomers to keep abreast of new developments, and for scientists beginning work on government moon projects to orient themselves.

This lack has now been partly filled by *Structure of the Moon's Surface*. Its author, Gilbert Fielder of the University of London Observatory, is a leading figure in the active modern British school of selenographers. As an amateur who became a professional astronomer, he combines extensive observational experience with an understanding of the physics of the moon.

The merits of Dr. Fielder's book lie in its stress upon quantitative observations by modern methods and upon physical interpretations. The broad range of topics is specially welcome. There are extended chapters on the determination of mountain heights, and on the shape of the moon. Photometric observations of the lunar surface and studies of the polarization of moonlight are reviewed in detail. We are given a concise summary of the evidence on the amount of a possible lunar atmosphere.

In the second half of this volume, Dr. Fielder considers the various types of surface features and their origins. Particular emphasis is placed on ray systems and the lunar grid pattern. The latter topic is one to which the author has contributed many important new ideas. The chapter on rilles documents the conclusion that they are subsidence features, not cracks in the moon's crust.

Although rich in facts, the presentation is straightforward and mostly nonmathematical. The extensive bibliographies that accompany each chapter are quite complete for the English-language literature, but omit many important German writings. A notable omission from the discussion of selenographic co-ordinates is J. Franz's great catalogue of 1,366 positions, published in 1913 under the title *Die Randlandschaften des Mondes*. Despite its linguistic bias, Dr. Fielder's check list of technical literature about the moon is a very helpful guide.

In certain other respects, *Structure of the Moon's Surface* could have been a better book. Parts of it are a choppy succession of brief summaries of published papers, important and valueless ones mingled haphazardly together, with little critical comment or analysis. Generally speaking, the strongest sections are those dealing with lunar physics and specific types of lunar formations. There the author is on familiar ground, and his material is better organized and digested.

The least satisfactory chapters are those describing librations and the figure of the moon. The former is weak and uninformative, the latter conveys several misunderstandings regarding the moon's physical libration.

A fairly large number of typographical errors occur. Such errors are especially easy to miss in numerical data, and hence numbers taken from this book should be checked against their original sources.

Caution in using the text is warranted by the following complex of error from page 16, in a discussion of mountain heights: "Many measurements made by Schroeter (1791; 1802) and Schmidt have

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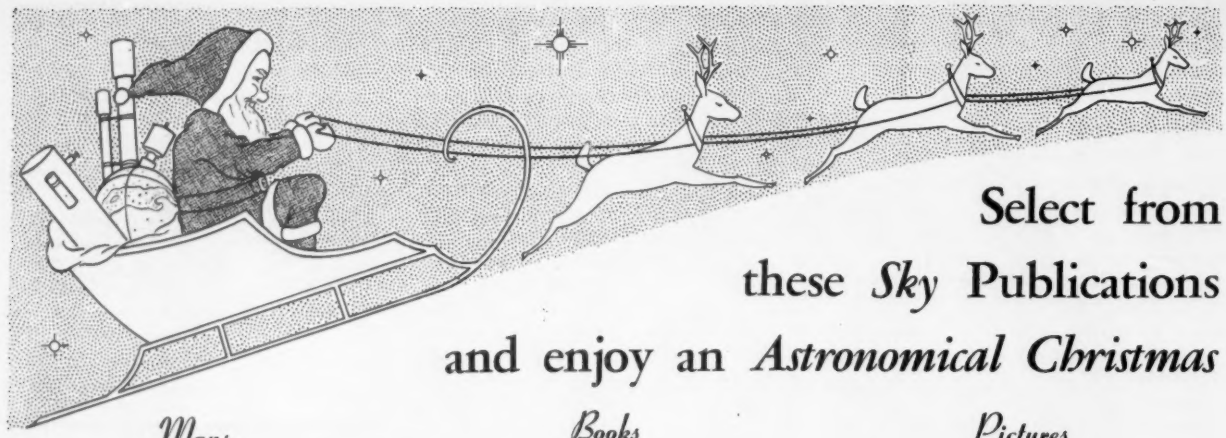

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The Lunik III Reconnaissance

On October 4, 1959, the Soviet Union successfully launched its third space probe, Lunik III, into orbit around the moon. Carrying a battery of intricate scientific equipment, including photographic and television systems, it passed near the moon, getting a first view of the part of the lunar surface that is perpetually hidden from our earth. On command it photographed the moon's far side for 40 minutes, and these images were later telecast to the earth.

The results of this achievement were compiled and edited for the U. S. S. R. Academy of Sciences by three Soviet astronomers, N. N. Barabashov, Kharkov University Observatory, A. A. Mikhailov, Pulkovo Observatory, and Yu. N. Lipsky, Sternberg Astronomical Institute. Dr. Lipsky summarized this work in SKY AND TELESCOPE for March, 1961, page 133. Now the complete Russian **Atlas of the Opposite Side of the Moon,** translated into English by Richard B. Rodman of Harvard Observatory, has been published jointly by Interscience Publishers, Inc., and Sky Publishing Corporation.

This English edition contains every fact, every illustration, in the Russian original. It includes an introduction, "The Photographs and Their Transmission," "Interpretive Techniques," "The Photometric Cross Sections," "Reduction of the Material," and replicas of all 20 full-page plates with their 30 halftone pictures of hitherto invisible lunar features. These pictures have been obtained by means of electronic filtration processes from the best original negatives taken by Lunik III. A major part of the book is the detailed catalogue identifying and describing 498 lunar formations. The definitive map is given in two forms — both as four full pages in the book, and as a 17-by-24-inch folding sheet. 200 pages (8⅜ by 11⅞ inches), 20 plates.

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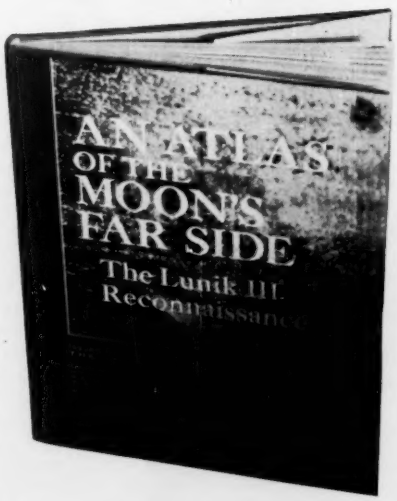

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been listed together with their own measurements in a table of 1095 mountain heights by Beer and Mädler (1873)." A correct statement would be: "Many measurements made by Schroeter (1791; 1802) and 1,095 by Beer and Mädler (1837) have been listed by Schmidt (1878) together with about 3,000 of his own measurements of mountain heights."

Despite its drawbacks, *Structure of the Moon's Surface* is a contribution of great value, if critically used. It deserves a revised second edition.

J. A.

METHODS OF CELESTIAL MECHANICS

Dirk Brouwer and **Gerald M. Clemence**, editors. Academic Press, New York, 1961. 598 pages. $15.50.

IT is an event of major significance when two of the foremost leaders in a branch of science collaborate on a presentation of their specialty in a form suitable for nonspecialist consumption. Such is the case in the book under review. D. Brouwer and G. M. Clemence are recognized as outstanding contributors to the field of celestial mechanics. The volume, therefore, reflects modern thought and methods in a branch of astronomy now very much in the forefront because of the interest in space science.

To quote from the preface: "Celestial mechanics may be studied as a mental discipline, to gain a general appreciation of principles and formal relations, or it may be studied with a view to practical applications. It is the latter that we have had exclusively in view. We give all of the principal methods that have been used most extensively for numerical calculations and none that are not suitable for the purpose." These sentences summarize in a nutshell the viewpoint taken by the authors.

The first chapters of the book develop the basic equations of elliptic motion, the series expansions required for representing the orbital parameters, formulas for gravitational attraction between bodies of finite dimensions (as opposed to particles), and the general integrals of the three-body problem. Included also are chapters on the calculus of finite differences, numerical integration, and the method of least squares. Numerical methods, therefore, are made available for those who have no particular background in this branch of mathematics.

An excellent feature of this book is the discussion in one chapter of aberration and other effects, such as precession, nutation, and geocentric parallax, which influence the positional co-ordinates required for a comparison between theory and observation.

The authors have assumed "a good working knowledge of differential and integral calculus" and "some knowledge of college algebra, the theory of equations, and ordinary differential equations" for a full understanding of the derivations. But it seems to the reviewer that much more mathematical sophistication and maturity are required on the part of the reader if he is to derive maximum benefit from this volume. Matrices are introduced at one point, and it seems logical that vector notation would have simplified parts of the presentation. In a few instances, the introductory material would have been made clearer by the inclusion of more detailed geometric illustrations.

Chapters XI to XVII, which constitute well over half the book, present the methodology for treating the theory of perturbations. These include the classical methods due to Lagrange and Hansen, as well as the methods of perturbations of co-ordinates to which the authors themselves have contributed so much. The lunar theory is used to illustrate these procedures. Chapters on the expansion of the disturbing function and on the use of canonical variables conclude *Methods of Celestial Mechanics.*

Although reference is given to current literature on numerical applications for the methods developed in the last half of the book, it seems to the reviewer that one or two such applications in situ would have been appropriate. This is true particularly for the student who might use the treatise as a text.

The format of the volume is pleasing. Samplings of the mathematical presentation throughout revealed very few misprints. For the advanced student in astronomy and for those scientists who, while not specialists in celestial mechanics, require some background in the subject, the book is a welcome addition to the literature.

S. W. McCUSKEY
Warner and Swasey Observatory

STELLAR ATMOSPHERES

Jesse L. Greenstein, editor. University of Chicago Press, Chicago, Ill., 1960. 724 pages. $17.50.

THIS MASSIVE BOOK, Volume VI of the long-awaited "Stars and Stellar Systems" series but the second to appear, encompasses the theoretical and observational aspects of stellar spectra. A score of astronomers present detailed reviews in 19 chapters, the topics ranging from stellar energy distribution to composite and combination spectra.

Although extreme specialization has been avoided in order to make the chapters suitable for graduate students and the increasing number of scientists in other fields requiring astronomical information, the book maintains a consistently high technical level.

The five opening chapters outline the theoretical analysis of stellar atmospheres, including the problems of spectrum lines. Corpuscular emission, magnetic fields, turbulence, rotation, and other physical

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phenomena not generally considered in first-order theory are treated in the next three chapters. The second half of *Stellar Atmospheres* contains 10 contributions describing specific types of stellar spectra, plus an account of isotopes in the atmospheres of stars.

A representative contribution is A. J. Deutsch's discussion of the mass loss from red giant stars. Although concentrating on the detailed spectral evidence for circumstellar gas surrounding late-type giants, his chapter presents an exciting insight into evolutionary processes. The radial velocities deduced from the circumstellar absorption lines indicate that gas from these stars is expanding out into space. Dr. Deutsch suggests that the principal loss of mass during a star's lifetime may take place in the *M*-giant stage.

The editor of the present volume, J. L. Greenstein, describes the spectra of a variety of subluminous stars, many of which provide significant information about the final stages in a star's history. These objects, lying below the main sequence on the H-R diagram, include old novae, SS Cygni variables, nuclei of planetary nebulae, and various types of subdwarf stars.

Costing a comparatively modest sum for such a comprehensive work, *Stellar Atmospheres* should find its way into the libraries of numerous astronomers and graduate students. Potential buyers of this book might wonder, however, to what extent it is equivalent to the four expensive astrophysics volumes of the *Handbuch der Physik* series. In spite of the similar subject material, little duplication occurs, largely because of the different approach and more extensive coverage of the present series.

"Stars and Stellar Systems" aims to present basic empirical information, co-ordinated and illuminated by theory in each area of astrophysics. In this volume the emphasis is on observational aspects of spectral analysis, in contrast to the more general, more theoretical, and sometimes more speculative orientation of the *Handbuch* volumes. Much of the presentation of stellar spectra here has no counterpart or only brief coverage in the *Handbuch.*

Some articles, potentially competitive, provide complementary material. For example, Dr. Greenstein's account of white dwarfs in the *Handbuch* is a virtual prerequisite to the corresponding section in the book under review. Similarly, a broad introduction to the theory of stellar atmospheres, such as D. Barbier's *Handbuch* article (in French), provides excellent background for G. Münch's swift-paced opening chapter.

In examining both of these comprehensive astrophysics series, one wonders whether they will achieve the relatively permanent niche gained by the old *Handbuch der Astrophysik* volumes. The field of stellar atmospheres is in a continuing state of development, and numerous papers have been published since late 1958, when the present volume was organized. Although some of the chapters were revised before publication, much of the book is already three years old. As the general editors for the series, Gerard P. Kuiper and Barbara M. Middlehurst, state in their preface, the more speculative parts of astronomy have been de-emphasized in order that the work may retain a greater degree of permanence. Only time will tell how successful this attempt has been.

From a 1961 vantage point, however, *Stellar Atmospheres* is a first-rate production and one of the most significant books of the year.

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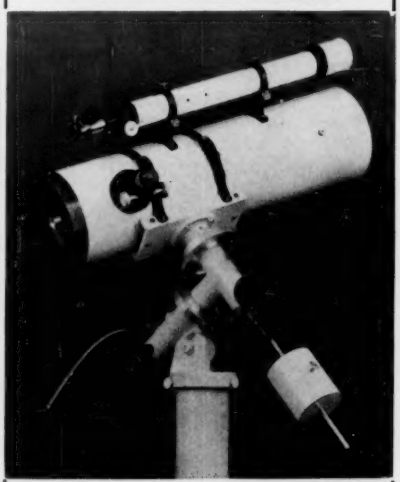

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NEW BOOKS RECEIVED

ADVANCES IN GEOPHYSICS, Vol. 7, *H. E. Landsberg* and *J. Van Mieghem*, editors, 1961, *Academic*. 333 pages. $11.00.

Well-documented articles on the progress of science in selected fields continue a series begun about a decade ago. Among topics discussed are controlled experiments on large-scale geophysical problems, by Dave Fultz; atmospheric tides, M. Siebert; and Arctic meteorology, A. D. Belmont.

MOON ATLAS, *V. A. Firsoff*, 1961, *Hutchinson and Co. Ltd.*, 178-202 Great Portland St., London W.1, England. 32 pages. 63s.

Four charts together show the near side of the moon to a scale of 18 inches to the lunar diameter, and are accompanied by a gazetteer and explanatory text. There are 14 photographs rectified to show portions of the moon as they would be viewed vertically to its surface. A large folding map in three colors represents the lunar grid system of clefts, furrows, faults, and ridges. Another colored foldout is a relief map of the moon nearly two feet across.

SPACE FOR EVERYONE, *Philip S. Egan*, 1961, *Rand McNally*. 72 pages. $1.50, paper bound.

Basic facts about the earth as a planet, the other members of the solar system, rocketry, and artificial satellites, are simply presented and illustrated with many diagrams.

OUR EMERGING UNIVERSE, *Allan Broms*, 1961, *Doubleday*. 296 pages. $4.95.

Recent theories of the origin and evolution of the universe, stars, and solar system are summarized for the general reader. Other chapters report current ideas about the moon's history, the interior of the earth, climatic changes, and life on the planets.

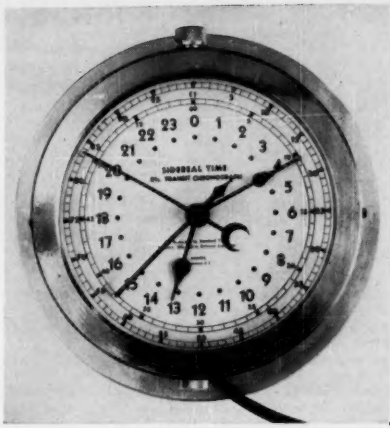
VOM POLARSTERN BIS ZUM KREUZ DES SÜDENS, *Helmut Werner*, 1960, *Gustav Fischer Verlag*, Stafflenbergstrasse 36, Stuttgart, West Germany. 239 pages. DM 34.00.

From Polaris to the Southern Cross is a detailed but elementary account of phenomena relating to the celestial sphere — time, rising and setting of stars, duration of day and night, and the constellations as viewed from different latitudes. Aimed especially at amateurs, the book uses no mathematics beyond arithmetic and simple geometry. Teachers and planetarium lecturers may find it a useful source of ideas. This German-language book is the enlarged third edition of a work published in 1942 and 1945.

CORRECTION

In the November issue, page 256, last column, the dates of the next passages of the earth through the ring plane of Saturn were given as December 13, 1965, January 12 and August 22, 1966, on the authority of J. G. Porter (*Journal* of the British Astronomical Association, January, 1960, page 52). These dates are incorrect, according to Edgar W. Woolard, director of the Nautical Almanac Office.

He writes: "The passages occur on April 2, October 29, and December 18, 1966. The date of June 15th for the passage of the sun through the plane is correct. These are the dates given by our own calculations, and also by Jean Meeus in an article in *Ciel et Terre, 73*, 54-56, 1957."



Exactly when did the phenomenon occur?

This picture was taken at precisely
13h 10m 37s.836 sidereal time, as you see.

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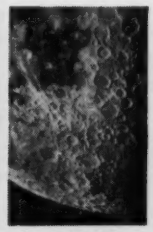
4. GREAT NEBULA IN ANDROMEDA



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From Mount Wilson and Palomar, Yerkes and Lick observatories come the classical exposures from which these dramatic 2-foot by 3-foot photographic-quality prints were made.

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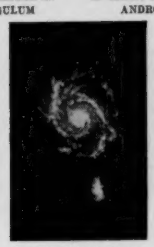
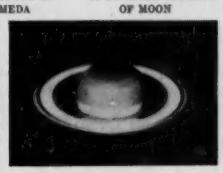


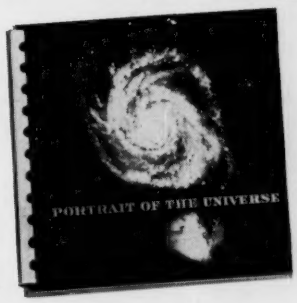
9. SPIRAL NEBULA IN CANES VENATICI



5. SATURN

7. SOLAR PROMINENCE

10. MOON—FOURTEEN DAYS



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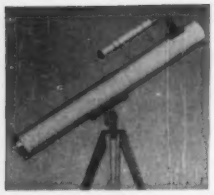

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60 to 180 Power
An Unusual Buy!

Assembled — ready to use! See Saturn's rings, the planet Mars, huge craters on the moon, star clusters, moons of Jupiter, double stars, nebulae, and galaxies! Equatorial-type mounting with locks on both axes. Aluminized and over-coated 3"-diameter f/10 primary mirror, ventilated cell. Telescope comes equipped with a 60x eyepiece and a mounted Barlow lens, giving you 60 to 180 power. A finder telescope, always so essential, included. Sturdy, hardwood, portable tripod.

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Bracket attaches permanently to your reflecting or refracting telescope. Removable rod with adjustable bracket holds your camera over scope's eyepiece, and you're ready to take exciting pictures of the moon. You can also take terrestrial telephoto shots of distant objects. Opens up new fields of picture taking!

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White metal screen is easily attached to holder and placed behind eyepiece. Point scope at sun, move screen to focus . . . and you can see sunspots!

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Includes brackets, 28¾" rod, projection screen, screws, and directions. Aluminum; brackets black crinkle painted.

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Real rack-and-pinion focusing with variable tension adjustment; tube accommodates standard 1¼" eyepieces and accessory equipment. Lightweight aluminum body casting (not cast iron); focusing tube and rack of chrome-plated brass; body finished in black wrinkle paint. No. 50,077-Y is for reflecting telescopes, has focus travel of over 2", and is made to fit any diameter or type tubing by attaching through small holes in the base. Nos. 50,103-Y and 50,108-Y are for refractors and have focus travel of over 4". Will fit our 2⅞" I.D. and our 3⅞" I.D. aluminum tubes, respectively.

For Reflectors

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For Refractors

Stock #50,103-Y..(for 2⅞" I.D. tubing)...**$12.95 ppd.**
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MASSIVE NEW 8" REFLECTOR

Designed Specifically for Schools, Colleges, and Serious Amateurs

Meets the most exacting requirements — provides years of rewarding study and viewing pleasure for the serious amateur. Also designed for astronomical courses in schools and colleges. Offers almost twice the light grasp of a 6" scope. Parabolic pyrex mirror hand corrected to better than ¼ wave, aluminized and overcoated. Matched set of precision-made, four-element, fluoride-coated orthoscopic eyepieces (6, 12.5, and 25 mm.) included. Telescope can be set on the excellent pedestal base described below. Because of its massiveness, we recommend mounting it on our completely new heavy-duty equatorial mount specifically designed for the purpose; vibration is minimized and stability guaranteed. Gray-wrinkle-finish mount has rugged phenolic 63" tube. De luxe wide-field finderscope, 5.5x, also provided. Full instructions. Shipping wt. approx. 200 lbs.

Complete 8" Telescope — including heavy-duty equatorial mount and pedestal base.
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Telescope Only — without equatorial mount or pedestal base.
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Setting Circles — beautiful and useful. Smooth-finished aluminum, 4" diameter, ½" thick. Engraved numbers and markings, black filled for night visibility. Center hole 2-11/16". Time and astronomy booklet included.
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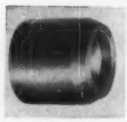
NEW WIDE-ANGLE TRIPLE T-LENS

ERFLE EYEPIECE



This quality eyepiece is particularly well suited for use in low-power telescopes, binoculars, and spotting scopes. Triplet lens consists of two achromats and simple negative lens. Effective focal length, 1¼". Made especially for wide-angle binoculars. Mounted in black anodized aluminum mount, 1-9/16" long, 1¾" in diameter. Fits standard 1¼"-O.D. eyepiece mount.

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Unmounted Lenses Only — spacing instructions included.
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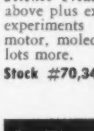

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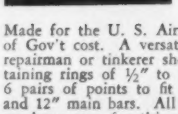

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This Edmund development adds real convenience to viewing objects on the earth. Just put the lens erector in your eyepiece holder, insert eyepiece, and focus normally. You see everything right side up and correct as to left and right. Made of polished chrome-finished brass telescoping tubing that will fit any standard 1¼" eyepiece holder. Tubing is 9½" long and slides 3" into eyepiece holder. Erecting system consists of two coated achromats.

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6X FINDER TELESCOPE

Has crosshairs for exact locating. You focus by sliding objective mount in and out. Base fits any diameter tube — an important advantage. Has 2 holders, each with 3 centering screws for aligning with main telescope. 20-mm.-diameter objective. Weighs less than ½ lb.

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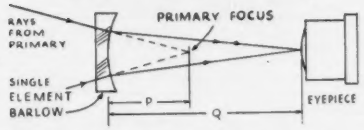
DOUBLE AND TRIPLE YOUR TELESCOPE'S POWER WITH A BARLOW LENS



WHAT IS A BARLOW? A Barlow lens is a negative lens used to increase the power of a telescope without resorting to very short-focal-length eyepieces, and without the need for long, cumbersome telescope tubes. Referring to the diagram above, a Barlow is placed the distance P inside the primary focus of the mirror or objective. The Barlow diverges the beam to a distance Q. This focus is observed with the eyepiece in the usual manner. Thus, a Barlow may be mounted in the same tube that holds the eyepiece, making it very easy to achieve the extra power. The new power of the telescope is not, as you might suppose, due to the extra focal length given the objective by the difference between P and Q. It is defined as the original power of the telescope times the quotient of P divided into Q.

Beautiful chrome mount. We now have our Barlow lens mounted in chrome-plated brass tubing, with special spacer rings that enable you easily to vary the power by sliding split rings out one end and placing them in other end. Comes to you ready to use. Just slide our mounted lens into your 1¼" I.D. tubing, then slide your 1¼" O.D. eyepieces into our chrome-plated tubing. Barlow lens is nonachromatic.

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For Exciting Telephoto Shots

Will fit any camera

Bring distant objects 7 times nearer with a 35-mm. camera, 7 x 50 binocular, and our BINOCULAR-TO-CAMERA HOLDER. Ideal for photographing constellations, star clusters, the moon, as well as cloud formations, wildlife, vistas. Camera and binocular attach easily. Use any binocular or monocular — any camera, still or movie. Take color or black-and-white. Attractive gray crinkle and bright chrome finish, 10" long. Full directions for making telephoto pictures included.

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MORE POWER FROM YOUR JAPANESE TELESCOPE

Mounted Barlow for Japanese Telescopes

By inserting this single-element lens in the eyepiece end of your Japanese telescope, and putting your regular eyepiece in the end of the Barlow tube, you can increase your telescope's power two or three times. Thus, instead of 60x, you will get 120x or 180x. Barlow is mounted in two pieces of telescoping brass tubing each 4" long, satin-chrome plated on the outside. Inner diameter of large tube and outer diameter of small tube are 0.965", the standard size for most Japanese telescopes. Measure yours before ordering. 0.965" is approximately 31/32" or 24.5 mm.

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UP TO 255 POWER

New Vibration-Free Metal Pedestal Mount

With this scope you can see the craters on the moon, the rings of Saturn, double stars. Mirror guaranteed to give theoretical limit of resolution. Rack-and-pinion focusing, removable mirror mount, counterweight. Real equatorial mounting — only one adjustment follows stars! Aluminum tube, 6x finder telescope. Two standard-size eyepieces and our mounted Barlow lens give you powers of 45x, 90x, 135x, 180x, and 255x. f/11 mirror corrected to better than ¼ wave length. **FREE** with Scope: Valuable **STAR CHART** plus 272-page **"HANDBOOK OF THE HEAVENS"** plus the book **"HOW TO USE YOUR TELESCOPE."** Shipping wt. 25 lbs.

Stock #85,105-Y.....**$74.50** f.o.b. Barrington, N. J.

Same telescope as described above but equipped with Electric Clock Drive.

Stock #85,107-Y.....**$109.00** f.o.b. Barrington, N. J.

Mounted Ramsden Eyepieces

Standard 1¼" Diameter

Our economy model, standard-size (1¼" O.D.) eyepiece. We mounted two excellent quality plano-convex lenses in black anodized aluminum barrels instead of chrome-plated brass to save you money. The clear image you get with these will surprise you. Directions for using short-focal-length eyepieces are included with both the ¼" and ½" models.

Stock #30,204-Y.....¼" focal length.....**$4.75 ppd.**

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STAR TIME CALCULATOR

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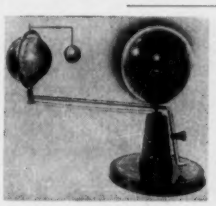
(B) FOR LIGHT-DUTY MOUNT (fits Edmund 4¼" reflector, 3" refractor). Black plastic, scales same as above. 1"-diameter hole; 3" outer diameter. Two pointers with 1¼"-diameter holes.

Stock #60,187-Y.....**$3.00 ppd.**



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Here is the story of cosmic motions — how the moon revolves around the earth, and the earth around the sun, with our planet rotating simultaneously. With this instrument, the observer sees a three-dimensional moving demonstration of how seasons, day and night, and moon phases occur. This handsome gear-and-chain-driven unit is supported by a smartly finished wood base. The sun is 6" in diameter, and the earth is 4". Planetarium is 12" high, base 8" wide; arm is 18" long. A completely illustrated, delightfully informative handbook included.

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Exciting New Low-Cost MOON MODEL

An Outer-Space Conversation Piece

Exact replica in relief, with 30,000 formations for study — peaks, craters, the 2-million-square-mile Ocean of Storms, etc. Formations scaled to size. Distance relationships held to close tolerances. A valuable teaching aid and outer-space display for museums and institutions. With proper lighting it shows moon phases; "black light" produces spectacular effects! Made of tough, washable plastic in three colors, can be marked without damage. Reverse side is blank to provide room for present and future space data. Wonderful gift for amateur astronomers and space enthusiasts. Exciting conversation piece for living room or den. 12" diam., wt. ¾ lb. Priced remarkably low.

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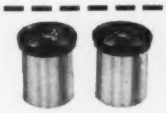

Finest quality. They are precision machined, mounted in standard 1¼" outside diameter barrels. Can be taken apart for cleaning. Designed to give sharp flat field clear to edge.

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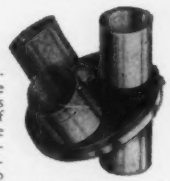
Orthoscopic 4-mm. f.l. (5/32")	**14.50**

Revolving Turret



The Criterion Revolving Turret holds three eyepieces so that, as desired, the power of the telescope can be changed by merely turning the turret to a different ocular. Click stop insures positive and accurate positioning of each eyepiece. Turret holds eyepieces of standard 1¼" outside diameter. Fits into the holder of any refractor or reflector telescope that uses 1¼" eyepieces. Requires no alteration or adjustment and can be attached as easily as putting eyepiece into scope. Made of brass and aluminum with polished chrome-plated barrels.

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The most mechanically perfect focusing is by rack and pinion. This mount takes standard 1¼" eyepieces. Full 3½" of travel — more than ever before. Accommodates almost any type of eyepiece — positive and negative. Two knurled focusing knobs, variably tensioned and positioned. Solid cast-metal sliding brass tube — close tolerance prevents looseness. Mount aligns itself to any type tube. Four mounting holes, nuts and bolts included. Eye mount has square-rod-type diagonal holder which prevents loose alignment and vibration. Rod tempered to minimize temperature changes. Adjustable for 3" to 8" scopes, also 12" scopes if so specified at no extra cost. Order one or more of the complete eyepieces described below at the same time you send for this rack-and-pinion device, which accommodates any of our eyepieces perfectly.

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Same features as above but has wider base that is contoured to match the curve of a 7" to 8" diameter tube. Makes professional appearance. Furnished without Diagonal Rod.....**$9.95**

Diagonal Rod — Cat. #SU-9R.....**$1.00**

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Our 16.3-mm. Erfle wide-angle eyepiece has a 75° field. Astonishing wide-angle views. Coated. Highest precision and specifically designed for telescopic use. Chrome barrel. Guaranteed to be superior in every respect.

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Cat. #	Minor-Axis Size	For Tubes	Price
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S-53	1.50"	8½" to 9½"	**10.00**
S-54	1.75"	9½" to 10½"	**12.50**
S-55	2.00"	11" to 11½"	**14.95**
S-56	2.50"	Specify tube I.D.	**19.95**

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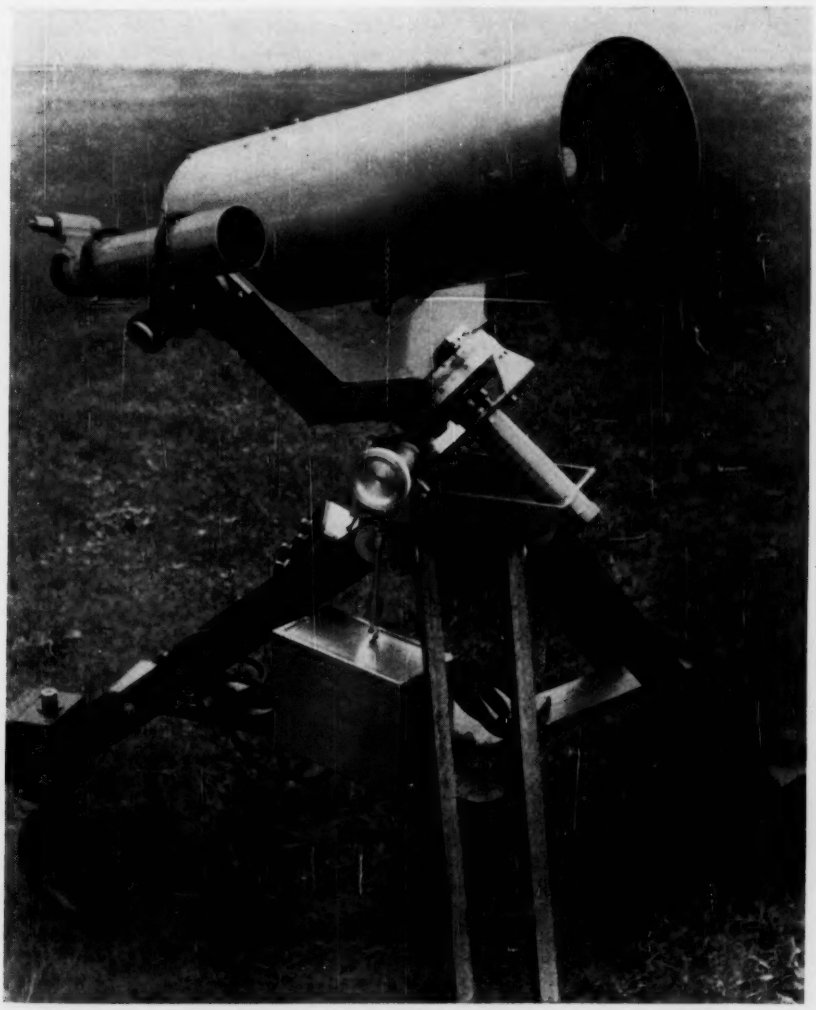
A Prize-Winning Gregory-Maksutov Telescope

SOME YEARS AGO I joined the ranks of women telescope makers by constructing a standard 6-inch Newtonian and a 6-inch rich-field telescope. Then I read John Gregory's article in Gleanings for March, 1957, describing his Maksutov instruments, and I knew it would be a lot of fun to make and use one. So I picked the f/23 design, which has a 6¼" aperture, and bought a mirror blank and a disk of optical glass for the corrector.

My husband Jim and I co-operated on the mounting design and he did the lion's share of its actual construction. I did get to turn a knob or two, the tripod being mostly my work. Jim was most pleased with the project, as he managed to acquire a lathe, drill press, and a gas-welding outfit.

All the optical work was done by me. The mirror was a fairly straightforward job, its spherical figure being quite easy to attain, as the radius of curvature is less than 44 inches (about f/3.5). Drilling the hole in the mirror was a new experience. I centered the blank on a rotating turntable and lowered a jig holding a piece of tubing down onto it while feeding in carborundum and water. I cut the hole almost through to the face of the mirror after rough grinding and finished the job after polishing.

Although a small grinding machine was used for some of the mirror surfacing, the corrector was completely ground by hand. A couple of 6" glass tools were used, the difference in diameter between them and my 6⅞" lens blank causing no difficulty. Altogether, it took me approximately 15 hours per side to rough in the steep curves



The 6¼-inch f/23 Maksutov telescope built by James and Diane Lucas, which won first prize for mechanical excellence and fourth prize for optics at the 1961 Stellafane convention of amateur telescope makers. The motor drive and setting circles were added after the telescope had been in use about a year.

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★ Red rouge and pitch

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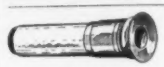
Focal length 24". Completely mounted with iris and shutter. Excellent for wide-field telescope. All in excellent condition. Price **$25.00**



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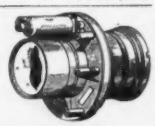
BELL & HOWELL f/8 TELEPHOTO LENS



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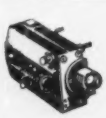
16-mm. AERIAL GUN CAMERA, MODEL AN-N6



Takes standard 16-mm. magazine load (50'). Takes 16, 32, or 64 frames per second. Wollensak Type V lens, 35-mm., f/3.5. Excellent condition. Uses 24-volt d.c.
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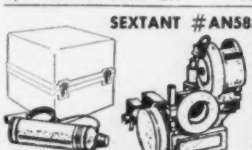

Bubble type (with alternate averaging device). Mfgd. by Bendix. Unit contains a horizontal indicator, a precision averager (for two-minute readings), an astigmatizer lens, bubble-level prism, spring-wound motor, etc., with carrying case. Shipping weight 20 lbs. Price **$12.50**

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(approximately 8" radii) on the concave and convex surfaces. Unfortunately, I had bought flat blanks before learning that Hayward Scientific Glass Corp. has them with the rough curves molded right in. Smoothing and fine grinding went more rapidly, since optical glass cuts faster than pyrex; however, it also scratches more easily.

The slowest part of the lens grinding process was the constant checking of wedge and thickness and the radii of curvature of its two surfaces. In making a Maksutov, tooling is all-important, especially obtaining a good spherometer. On the secondhand lathe my husband made a ring-type spherometer with an outside diameter of 5.9". When this was used with a 0.0001" micrometer it was not difficult to hold the radii well within tolerance (0.070"). Edge thickness was checked with a 1" micrometer, and a friend with a surface plate and a dial gauge measured the central thickness several times.

I didn't make any optical measurement of the radii of the corrector. But it is easy to obtain the difference in position of the two apparent centers of curvature, by means of a precision Foucault tester. This check also serves as a control on the spherometer measurements during grinding.

We denote by d the distance between the images reflected from the two surfaces of the corrector, the light from the second surface being refracted twice in passing through the glass. The formula quoted by Franklin B. Wright in *Amateur Telescope Making — Book Three* (page 577) is incorrect, and the expression given by Norman Cole in Maksutov Club *Circular* 26 should be used instead. To simplify its application, write

$$d = R_1 - 1/x,$$

and

$$x = n/(R_2 - t) - (n - 1)/R_1.$$

R_1 is the radius of curvature of the concave surface, R_2 that of the convex; t is the central thickness of the corrector lens; and n is the index of refraction of its glass.

For testing the figure of the steep corrector surfaces, I used the wide-angle light source described by Henry E. Paul in *Amateur Telescope Making — Book Three*, page 327. This uses a microscope objective to image the pinhole and a microscope cover glass as a beam splitter to allow testing on the optical axis. As suggested in a former Gleanings column, I had two eyepieces back to back as a low-powered telescope for viewing the surface under test; my eyepieces were a 28-mm. orthoscopic and a 16.8-mm. Erfle.

The polishing lap for the concave side was made on its glass tool by painting a thin coat of beeswax on the glass and sticking to it slightly warmed squares of pitch, which had been formed in a wooden mold lined with aluminum foil. For the convex side a wooden disk was turned from two pieces of ¾" plywood, glued together to secure adequate thickness. One face was turned to a concave radius equal to that of the convex lens surface, and the

disk was then soaked in paraffin. Pitch squares were applied as described above. The pitch was soft on both laps, tempered with castor oil, and I had no trouble getting contact and polishing out the surfaces.

With very little work, the concave side of the lens yielded a spherical figure and the convex showed spherical on the first test at the end of polishing. Both the Foucault and Ronchi tests were employed, but on the convex only the Ronchi gave a clear view. Two sets of Ronchi bands were seen with different spacings, those belonging to the convex surface being the dimmer.

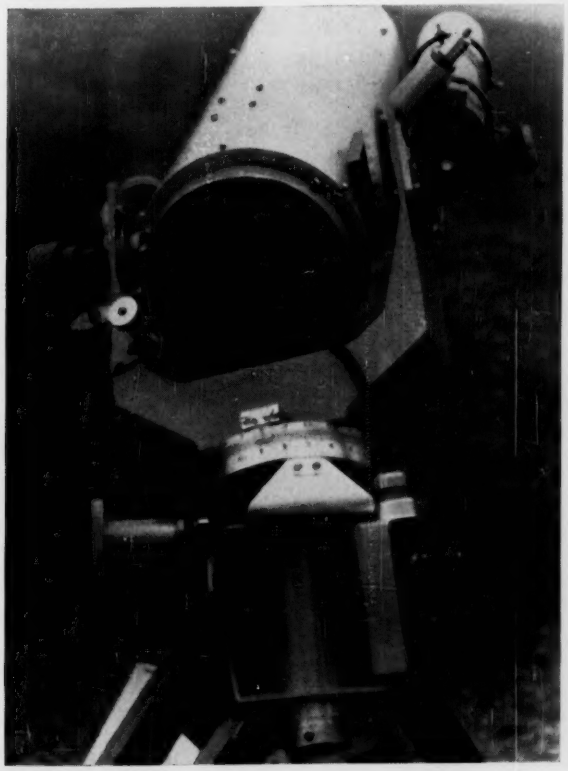
In order to autocollimate the Maksutov, an 8-inch flat was ground and polished to a final figure of 1/10 wave or better. I found this an interesting project in itself. Aligning the optics for autocollimation is not easy the first time. I did this roughly by looking through the hole in the primary and putting the light source in position. The on-axis tester and a Ronchi screen with 100 lines per inch were used. With the light source turned on and the eye placed back and to one side, in a darkened room it is possible to see along the optical axis a series of images of the pinhole or slit. The positions of the mirror, flat, and lens were adjusted until all the images lined up exactly. The test image would then be found in its proper place. This method may be used when testing refractor objectives by autocollimation, the same type of images then being seen.

It is possible on the Maksutov to see the test pattern even if the primary is bare glass, but it is much easier if the mirror has been given a reflecting coating. The secondary spot *must* be aluminized, as the pattern is seen coincident with that area.

First tests on the collimated setup showed the combination of lens and mirror to be overcorrected, the Ronchi bands indicating the familiar parabolic sweep. Although my other tests had showed spherical optics on all elements, this overcorrection was probably due to the radii of the lens being 0.012″ short of design specifications. So I used a petal lap somewhat like that of Warren I. Fillmore (*Construction of a Maksutov Telescope*, page 18), but with a hole in the middle to avoid working on the center of the mirror too much. However, the mark was overshot, the bands now showing an undercorrected pattern. A full-size lap was then used to bring the mirror back to a sphere, and by juggling the work between the two laps complete correction was obtained.

Need for thus aspherizing a Maksutov-Cassegrainian arises from three factors: elements that are not figured precisely spherical, departures from exact design values, and aberrations inherent in all spherical systems. Smoothness of the primary mirror is most important, as the secondary amplifies minute irregularities (about seven times for the f/23) until they show up like sore thumbs in the autocollimation test.

Our mounting was designed in expectation of using the telescope quite a bit and not just admiring it. A coude diagonal in front of the primary deflects the focus to a point on the declination axis outside of one of the fork trunnions. This position is convenient for observing, and allows



In the Lucas' versatile telescope mounting, the eyepiece and finder on the right side of the tube are balanced by counterweights on the left. The primary mirror has a ring-shaped weight, in the center of which is part of the support mechanism for the diagonal flat. The right ascension circle is double, with one pointer on the polar axis and another on the telescope fork. Setting circles may be turned independently or as a unit. At the start of observing, the telescope is pointed toward a bright star whose right ascension is set on the upper circle. Clock or watch time is set on the other, after which the two circles are turned as a unit by the drive mechanism. The upper circle then provides a right ascension scale for subsequent pointings on any other celestial object.

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cameras or other equipment mounted there to be easily balanced by weights on the other trunnion. The diagonal is supported by a holder that passes through the hole in the primary mirror, eliminating spider diffraction.

The back plate on the tube supports the diagonal holder, the mirror cell by three pairs of push-pull screws, and a counterweight. The position of the corrector lens is also adjusted by push-pull screws. Aligning the optics was not difficult, rough positioning being done by daylight and final adjusting at night on the out-of-focus rings of a bright star. The lens and mirror were adjusted until the rings were concentric and the focus was in the correct position with respect to the eyepiece holder.

The fork is of welded steel plate. Self-aligning ball bearings are carried in the fork trunnions to support the telescope tube, while the 1¼" steel polar axle is set in bronze bushings. For manual declination slow motion, a spring-loaded screw operates a lever clamped to one of the trunnions. For motion in right ascension, the fork may be turned by hand, or by a large knob on each side of the fork base, or by the hand-held electric control box. This operates a sidereal drive, with provision for fast speeds forward and reverse. The motors are located in the box on the tripod shelf. Two friction clutches in the drive train allow different modes of movement simultaneously, one where the main drive gear is free to slip on the polar axis and the other at the next gear reduction.

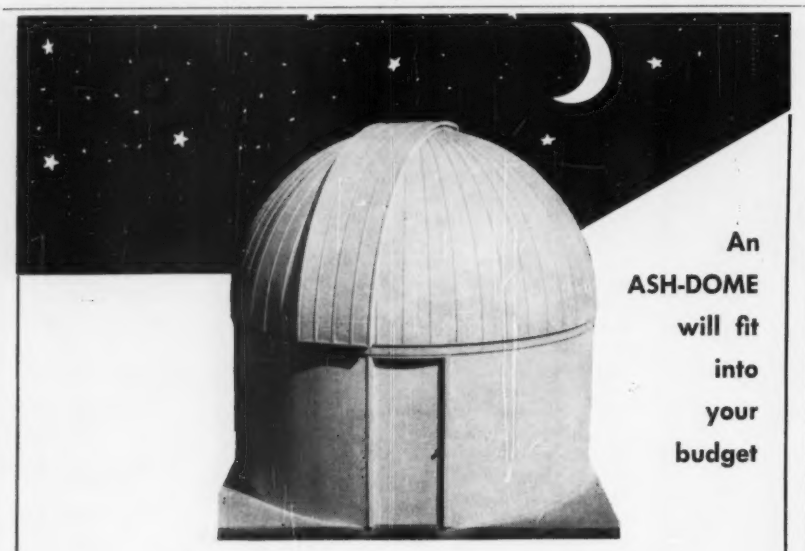
Our setting circle for declination is conventional, but the pair of circles on the polar axis is not, being copied from a 12-inch Cassegrainian of W. A. Mason, Lorain, Ohio. One nice feature of the double-circle system is that any available time can be used: Eastern standard, daylight saving, or the old grandfather clock that is always 29 minutes slow!

Because of the low tripod, a box 1 by 1½ by 2 feet can be used as a chair in all observing situations. The wheels and detachable handle make it very easy to set the telescope up for an evening of observing. Usually the instrument is steady and the wheels do not have to be chocked. The finder covers a six-degree field, so the Maksutov needs only an approximate pointing to the celestial pole for the setting circles to be useful.

How much did it cost? Including the outlay for a few mistakes, we spent $195. If we were doing it again, the only change I would make would be the f/15 design instead of the f/23, as I am interested especially in variable star observing rather than lunar and planetary work.

How long did it take to build? Our elapsed time was 2½ years, for the mounting and tripod, to make the optics, to build a house, and have two baby daughters! We have just acquired an 11-inch Maksutov corrector lens blank for our next project.

MRS. DIANE LUCAS
145 Carol Lane
Elyria, Ohio



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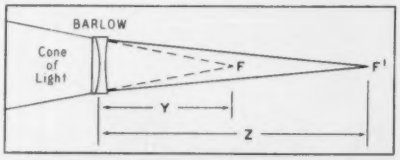
THE USE OF A BARLOW LENS

ONE of the most useful telescope accessories is a concave lens that may be inserted a short distance inside the focus of the objective or mirror. This Barlow lens increases the equivalent focal length of the system, and hence the power, by an amplification factor whose numerical value depends upon the location of the lens. The device, which may be either a simple lens or an achromat, works equally well with reflectors and refractors, and produces only a small increase in the over-all length of either type of optical system.

The accompanying diagram shows how a Barlow is used. Its action is similar to



The manner in which a Barlow lens increases the power of a telescope is illustrated here. The angle of convergence of the focused light rays is made much smaller, the apparent increase in focal length producing higher power with any particular ocular.

that of the rear element of a telephoto lens or the convex mirror in a Cassegrainian telescope system. Without the Barlow the image would be formed at **F**, the prime focus of the objective. When the Barlow is inserted at a distance **Y** inside the focus, a new image will be produced at **F′**, at distance **Z** from the auxiliary lens position.

By changing **Y** and **Z**, any desired amplification A can be obtained, this factor being **Z**/**Y**. If the Barlow is placed at **F** itself, no amplification results, while if **Y** equals the negative focal length of the lens no real image is formed at **F′**, this second situation being in effect that of the negative eyepiece in a Galilean telescope.

For a given Barlow lens of focal length f, a chosen amplification may be obtained by these relations:

$$\mathbf{Y} = f(A - 1)/A, \quad \mathbf{Z} = f(A - 1).$$

Assume that the sketch represents a Barlow of 5″ focal length placed in the cone of light of a telescope. Let us suppose a power of 100x is desired for an eyepiece that used alone would give 50x, that is, the amplification is to be 2x. Then $\mathbf{Y} = 5(2 - 1)/2$ or 2½″ and $\mathbf{Z} = 5(2 - 1)$ or 5″. With an increase in overall tube length of only 2½″, the effective focal length of the telescope has been doubled. A 75x eyepiece will give 150x with the Barlow, 100x increases to 200x, and so on. This amplification is the primary advantage of the Barlow lens. For any one setting of the device, every ocular has two powers, one with and one without the Barlow in the optical train. And by resetting the auxiliary lens other ranges of powers can be employed.

A second advantage is that the Barlow reduces the steepness of the convergence of the cone of light. For instance, at 2x the f/8 cone of the typical 6-inch reflector is changed to f/16, normal for a refractor, which gives better eyepiece performance.

Finally, high powers can be reached even with eyepieces of long focal length, resulting in greater eye relief and more comfortable viewing. Without a Barlow, a power of 300x would require using a ⅛-inch eyepiece for a reflector of 50″ focal length. Such a short eyepiece is difficult to make, has extremely small, expensive lenses, and a very short eye relief. Instead, a 3x Barlow will get the same result with an easily obtained ½-inch ocular.

Some fabulous claims have been made for improved telescope performance using this auxiliary lens. But there is nothing mysterious about a Barlow's function, and it will emphasize rather than overcome the faults of a poor instrument. A fine-quality achromatic Barlow will give good results up to 3x under average seeing conditions, and can provide even higher amplification if necessary. A nonachromatic or simple negative lens is limited to a useful amplification of about 2x.

RALPH K. DAKIN
720 Pittsford-Victor Rd.
Pittsford, N. Y.

ED. NOTE: It is comparatively easy to find the focal length of a negative lens that is to be used as a Barlow. First, use a small convex lens (for example a finder objective) to form an image of a light source placed about two feet in front of it. The exact distance from source to lens is unimportant, as we are only interested in the immediate vicinity of the focal point, that is, the area shown in Mr. Dakin's Barlow diagram.

Place the negative lens to be tested so its center is exactly 1″ inside the focus of the test lens, producing a new image of the source. Since the distance **Y** is 1″, measurement of **Z** will give the amplifying factor, and the Barlow's focal length is equal to $\mathbf{Y}A/(A - 1)$. For instance, if the Barlow-to-new-focus distance were 1¼″, its focal length would be 5″.

R. E. C.

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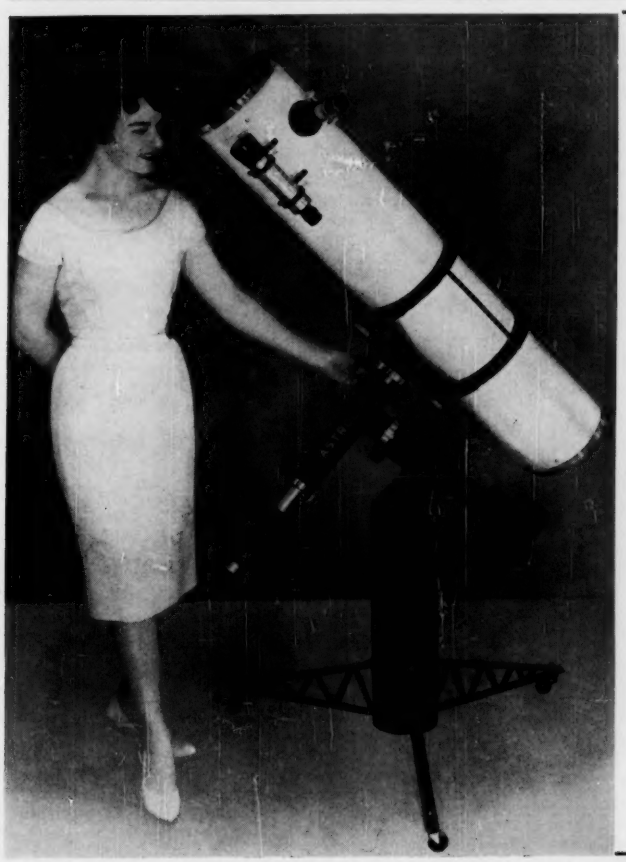

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Here we present our new 8″ f/6 De Luxe ASTROLA on a portable equatorial mounting with clock drive, setting circles, an 8x 52-mm. finder, and three of the finest orthoscopic oculars. This telescope can be completely disassembled in less than three minutes.

Price, complete, $590.00

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6″	$325.00	$500.00
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6″	$60.00
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UNITRON
MONTHLY REPORT TO OBSERVERS

SEE THE BACK COVER FOR MORE NEWS ABOUT *UNITRON*

constellation of the month

TAURUS

Whether you observe with a UNITRON or the unaided eye, Taurus the Bull is a particularly attractive region of the winter evening sky. It is easily located by looking first at Orion's Belt in the southeast, then continuing the line of these three stars upward to find the brilliant orange star Aldebaran, in the Bull's head.

This star lies amid a fine V-shaped clustering of bright stars, the Hyades. For looking at this extended group, a UNITRON view finder used as a hand-held telescope is very effective, because of its wide field and good light-gathering power.

A second famous Taurus cluster is the Pleiades, striking to the naked eye as a compact knot of six or more stars. Seen with a low-power eyepiece on your UNITRON, the Pleiades form a beautiful miniature constellation of over a hundred glittering points of light. Both this cluster and the Hyades are favorite subjects of the amateur astrophotographer.

Users of 3" UNITRONS (like the instrument pictured on the back cover of this issue) will find Aldebaran to be a wide double star with components of very unequal brightness. The dim 11th-magnitude companion is two minutes of arc from its 1st-magnitude primary. (This distance is about 1/15 the apparent width of the full moon's disk.) Another, closer pair is 118 Tauri, magnitudes 5 and 7, with a five-second separation, readily split in small refractors.

Select a very clear, moonless night for looking at the Crab nebula, located about one degree northwest of the star Zeta Tauri. It can be seen as a faint, oval glow in a 3" UNITRON, but the superior light-grasp of the 6" UNITRON gives better results. This dim patch of light is the gaseous remnant of a supernova that blew up in the year 1054.

In the eastern part of Taurus, bordering on Gemini, the Milky Way contains numbers of red stars. With the aid of a star atlas, such as Norton's, it is easy to identify fine examples, including Y Tauri and 119 Tauri. The former, which is near Zeta, is a 7th-magnitude object of a striking crimson hue.

24, XXIV, TWENTY-FOUR UNITRON MODELS TO CHOOSE FROM!

Now that all UNITRON Equatorials are available with Synchronous Motor Clock Drives, the prospective buyer has an even greater number of models from which to choose. In fact, unless we are mistaken, UNITRON now offers a wider selection than at any time in the history of the refractor.

All models come complete with mounting, tripod or pier, eyepieces, Achromatic Amplifier, accessories, and cabinets. While additional eyepieces and accessories are available for most models, the assortments included as standard equipment will be found remarkably complete.

2" SATELLITE (**$7.50 Down**) 6x, diagonal eyepiece, altazimuth mount with circles, stand — **$75**

1.6" ALTAZIMUTH, Model 127 (**$7.50 Down**) with eyepieces for 78x, 56x, 39x — **$75**

2.4" ALTAZIMUTH, Model 114 (**$12.50 Down**) with eyepieces for 100x, 72x, 50x, 35x — **$125**

2.4" EQUATORIAL, Model 128 (**$22.50 Down**) with eyepieces for 129x, 100x, 72x, 50x, 35x — **$225**

2.4" EQUATORIAL, Model 128C (**$27.50 Down**) same as Model 128 but with motor drive also — **$275**

3" ALTAZIMUTH, Model 140 (**$26.50 Down**) with eyepieces for 171x, 131x, 96x, 67x, 48x — **$265**

3" EQUATORIAL, Model 142 (**$43.50 Down**) with eyepieces for 200x, 131x, 96x, 67x, 48x — **$435**

3" EQUATORIAL, Model 142C (**$49.50 Down**) same as Model 142 but with motor drive also — **$495**

3" PHOTO-EQUATORIAL, Model 145 (**$55.00 Down**) with guide telescope, etc., and 6 eyepieces — **$550**

3" PHOTO-EQUATORIAL, Model 145C (**$61.00 Down**) same as Model 145 but with motor drive also — **$610**

4" ALTAZIMUTH, Model 150 (**$46.50 Down**) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x — **$465**

4" EQUATORIAL, Model 152 (**$78.50 Down**) with eyepieces for 250x, 214x, 167x, 120x, 83x, 60x, 38x — **$785**

4" EQUATORIAL, Model 152C (**$84.50 Down**) same as Model 152 but with motor drive also — **$845**

4" PHOTO-EQUATORIAL, Model 155 (**$89.00 Down**) with guide telescope, etc., and 7 eyepieces — **$890**

4" PHOTO-EQUATORIAL, Model 155C (**$95.00 Down**) same as Model 155 but with motor drive also — **$950**

4" EQUATORIAL, Model 160V (**$98.50 Down**) with weight-driven clock drive, etc., and 7 eyepieces — **$985**

4" PHOTO-EQUATORIAL, Model 160 (**$117.50 Down**) same as Model 160 but with guide telescope, astro-camera, etc., and 8 eyepieces — **$1175**

4" EQUATORIAL, Model 166V (**$107.50 Down**) with weight-driven clock drive, metal pier, etc., and 7 eyepieces — **$1075**

4" PHOTO-EQUATORIAL, Model 166 (**$128.00 Down**) same as Model 166V but with guide telescope, astro-camera, Super-UNIHEX, etc., and 10 eyepieces — **$1280**

5" PHOTO-EQUATORIAL, Model 510, with clock drive, guide telescope, astro-camera, etc., and 10 eyepieces — **$2275**

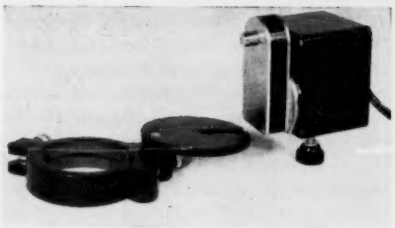
5" PHOTO-EQUATORIAL, Model 530, same as Model 510 but with metal pier instead of tripod — **$2385**

6" EQUATORIAL, Model 600, with clock drive, metal pier, etc., and 10 eyepieces — **$5125**

6" PHOTO-EQUATORIAL, Model 610, same as Model 600 but with guide telescope, astro-camera, etc. — **$5660**

6" PHOTO-EQUATORIAL, Model 620, same as Model 610 but with 80-mm. astrographic camera also — **$6075**

(Special payment plan available for 5" and 6" Models.)



accessory of the month

MOTOR CLOCK DRIVES

Synchronous Motor Clock Drives are now available for all UNITRON Equatorial Models. With one of these drives to track celestial objects for you, observing with your UNITRON will be more convenient than ever. For UNITRON Clock Drives are the result of careful planning and design to achieve certain definite goals that you, the observer, have requested.

The drives are designed so that they may be readily added to the many UNITRONS now in use without the need for any special adaptation. The rugged synchronous motor is mounted in an attractive metal housing to which is attached a compact reduction-gear assembly. A thumbscrew locks the housing to a small shelf which, in turn, clamps to the base of the equatorial mount, above the tripod head. The output shaft of the gear system connects directly to the right ascension hand drive knob. This method of coupling, using as it does the regular worm-gear mechanism of the telescope, insures stability of the tube and eliminates the "play" that is often found in drives that connect directly to the polar axis. It takes but a minute to attach the drive, or to remove it for terrestrial observation or when you are viewing outdoors, away from a 110-volt outlet.

The resulting arrangement is shown in the picture of the UNITRON 2.4" Equatorial on the facing page. Recent UNITRON Equatorials have a right ascension knob drilled to accept the flexible-cable slow motion, and the same hole is used as the connector to the gear box. For earlier models, a replacement control knob of the newer type will be supplied with the drive at no additional charge.

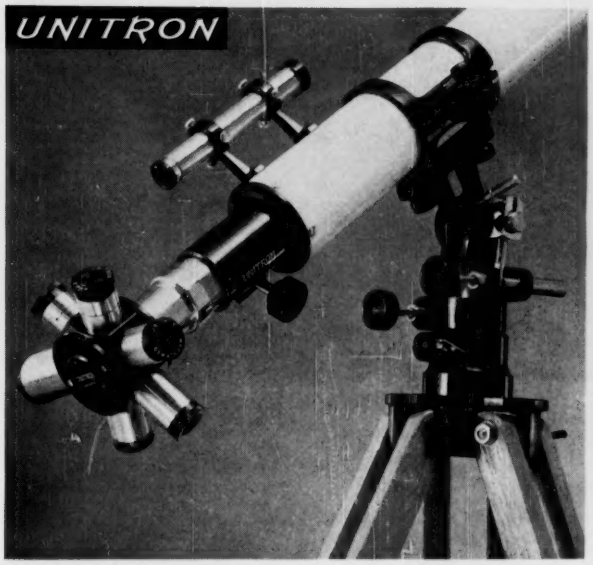
The prices for the motor drive are remarkably low for precision mechanisms of this type.

For 2.4" MODEL	**$50.00**
For 3" MODEL	**$60.00**
For 4" MODEL	**$60.00**

These prices are postpaid and include the complete assembly: motor, gear box, and special shelf.

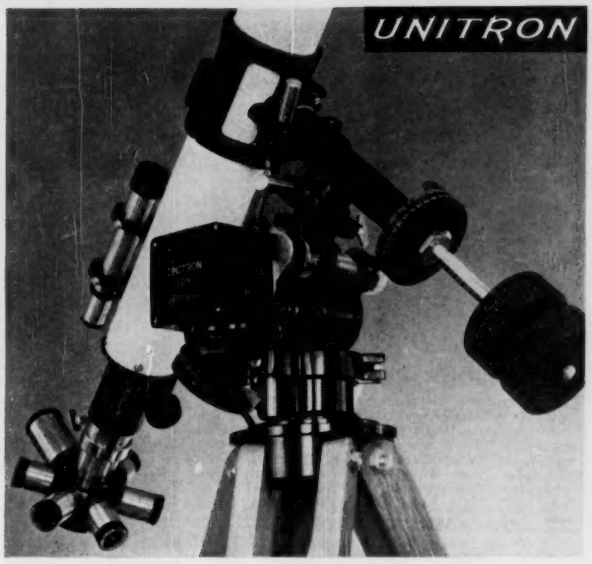
If you are not already a UNITRON owner, you will want to refer to the listing in the preceding column and note the many clock-drive models which are now available. If you already have a UNITRON Equatorial, what better occasion is there than Christmas to bring your telescope up to date with one of these new drives? Since only a limited number of motor drives will be available for shipment before Christmas, it is not too early to order or reserve yours now. Our phone is Area Code 617, WOodward 9-8600.

Give or Get a UNITRON 2.4-inch Refractor this Xmas!



UNITRON 2.4" ALTAZIMUTH REFRACTOR

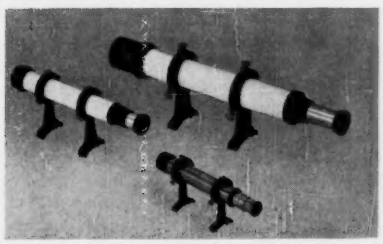
America's most popular low-priced refractor has long been a favorite with the beginner and advanced amateur alike. It duplicates the performance of larger telescopes of other types. Complete with tripod, sturdy mounting with micrometric slow-motion controls, UNIHEX Rotary Eyepiece Selector, four eyepieces, Achromatic Amplifier, sunglass, and suitcase-type carrying case. **$125**



UNITRON 2.4" EQUATORIAL REFRACTOR

Our new 2.4" Equatorial now offers setting circles at no increase in price. In addition, the Synchronous Motor Clock Drive (shown here) may be added for the modest price of $50. A supplementary slow motion has been included to change the right ascension while the clock is running. Price includes five eyepieces and same accessories as the Altazimuth model, without clock drive. **$225**

UNITRON'S POPULAR VIEW FINDERS



1. **VIEW FINDER**, 23.5-mm. (.93"), 6x eyepiece. **Postpaid, only $8.50**
2. **VIEW FINDER**, 30-mm. (1.2"), 8x eyepiece. **Postpaid, only $10.75**
3. **VIEW FINDER**, 42-mm. (1.6") air-spaced objective, 10x eyepiece. **Postpaid, only $18.00**

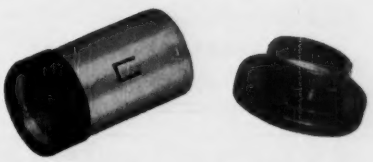
USE OUR EASY PAYMENT PLAN

UNITRON's popular Easy Payment Plan is a convenient and economical way to buy your UNITRON Refractor. The down payment required is 10%. The balance due is payable over a 12-month period, and there is a 6% carrying charge on the unpaid balance. Your first payment is not due until 30 days after you receive the instrument, and if you should want to pay the entire balance due at that time, the carrying charge is cancelled.

There is no "red tape" when you order — you merely fill in the UNITRON Easy Payment Order Form, return it together with the required down payment, and the model of your choice is shipped to you at once.

Do not hesitate to use this plan merely because you have never before purchased anything on time payments. The procedure is practically painless and is an ideal means of enjoying the use of your UNITRON while paying for it.

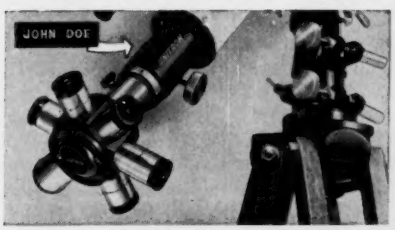
NEW ACHROMATIC AMPLIFIER NOW FREE with each UNITRON



The new UNITRON Achromatic Amplifier is a two-element, Barlow-type, negative amplifying lens designed especially for UNITRON Refractors. When used with a UNITRON eyepiece, it **doubles** the normal magnification of the telescope.

This useful and valuable accessory is now included as standard equipment with all UNITRON Refractors at no additional cost . . . another of the many reasons why the telescope you choose should be a UNITRON.

FOR JOHN DOE AND OTHERS



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CELESTIAL CALENDAR

Universal time (UT) is used unless otherwise noted.

MOON PHASES AND DISTANCES

New moon	December 7, 23:52
First quarter	December 14, 20:06
Full moon	December 22, 0:42
Last quarter	December 30, 3:57
New moon	January 6, 12:36

December	Distance	Diameter
Perigee 12, 0h	228,900 mi.	32′ 27″
Apogee 27, 19h	251,600 mi.	29′ 30″
January		
Perigee 8, 14h	225,300 mi.	32′ 57″

MINOR PLANET PREDICTIONS

Astraea, 5, 9.5. December 7, 6:52.8 +15-46; 17, 6:45.6 +15-58; 27, 6:36.4 +16-20. January 6, 6:26.5 +16-53; 16, 6:17.4 +17-31; 26, 6:10.7 +18-13. Opposition on December 29th.

After the asteroid's name are its number and the approximate visual magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

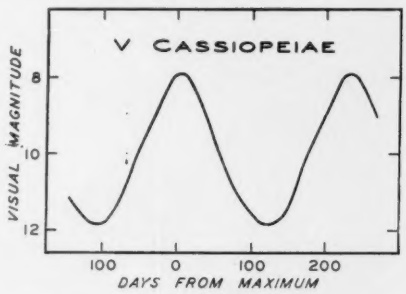
V CASSIOPEIAE

BOTH the Skalnate Pleso *Atlas of the Heavens* and Norton's *Star Atlas* mark the place of the long-period variable star V Cassiopeiae, at right ascension 23h 09m.5, declination +59° 26′ (1950 co-ordinates). This object has been a favorite with amateur observers of variables because it is relatively bright and has a convenient circumpolar location.

This winter, V Cassiopeiae will reach maximum light about December 13th, according to Mrs. M. W. Mayall of the American Association of Variable Star Observers, but the 1958 Moscow *General Catalogue* predicts maximum nine days earlier. This difference is only a small fraction of the 228-day average period, and moreover, individual cycles may be up to a fortnight longer or shorter than the mean value.

V does not always reach the same brightness at maximum, the peak being anywhere from magnitude 7.3 to 8.6, with an average of 7.9. At minimum, due about the beginning of April next year, the star's magnitude will be about 12. An interesting experiment for amateurs who do not have detailed maps is to make a careful plot of the stars in this area in December, and then, a month or so later, to compare the plot with the sky to rediscover V, if possible, by its decrease in brightness.

The actual discovery of the variability was made in a manner not too different from this, by Thomas Anderson of Edinburgh, Scotland, in 1893. This amateur painstakingly compared the *Bonner Durchmusterung* charts with the sky as seen in his 2½-inch refractor, and over the years discovered more than 40 long-period variable stars. Anderson had the unusual distinction of being the first to see two bright novae, that of 1891 in Auriga and Nova Persei 1901.



The nature of the light changes of V Cassiopeiae during an average cycle. This light curve was prepared by Leon Campbell from brightness estimates made over several decades by members of the American Association of Variable Star Observers.

MINIMA OF ALGOL

There are indications that recent Algol minima have been occurring earlier than predicted here, by a large fraction of an hour. New observations from which times of least brightness can be derived are urgently needed.

December 2, 11:02; 5, 7:51; 8, 4:41; 11, 1:30; 13, 22:19; 16, 19:08; 19, 15:58; 22, 12:47; 25, 9:36; 28, 6:26; 31, 3:15.

January 3, 0:04; 5, 20:53; 8, 17:43; 11, 14:32.

These minima predictions for Algol are based on a recent timing by D. Engelkemeir and an assumed period of 2.8674 days. The times given are geocentric; they can be compared directly with observed times of least brightness.

VARIABLE STAR MAXIMA

December 2, T Cephei, 210868, 6.0; 2, R Cassiopeiae, 235350, 7.0; 3, S Ursae Majoris, 123961, 7.8; 4, R Normae, 152849, 7.2; 4, Chi Cygni, 194632, 5.2; 7, T Centauri, 133633, 5.5; 11, V Ophiuchi, 162112, 7.5; 13, V Cassiopeiae, 230759, 7.9; 14, R Leonis, 094211, 5.8; 16, R Draconis, 163266, 7.6; 19, T Columbae, 051533, 7.5; 24, U Cygni, 201647, 7.2; 26, R Carinae, 092962, 4.6; 27, R Canum Venaticorum, 134440a, 7.7; 28, R Leonis Minoris, 093934, 7.1.

January 1, S Sculptoris, 001032, 6.8.

These predictions of variable star maxima are by the AAVSO. Stars are listed only if brighter than magnitude 8.0 at an average maximum. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the date given. The data include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted visual magnitude.

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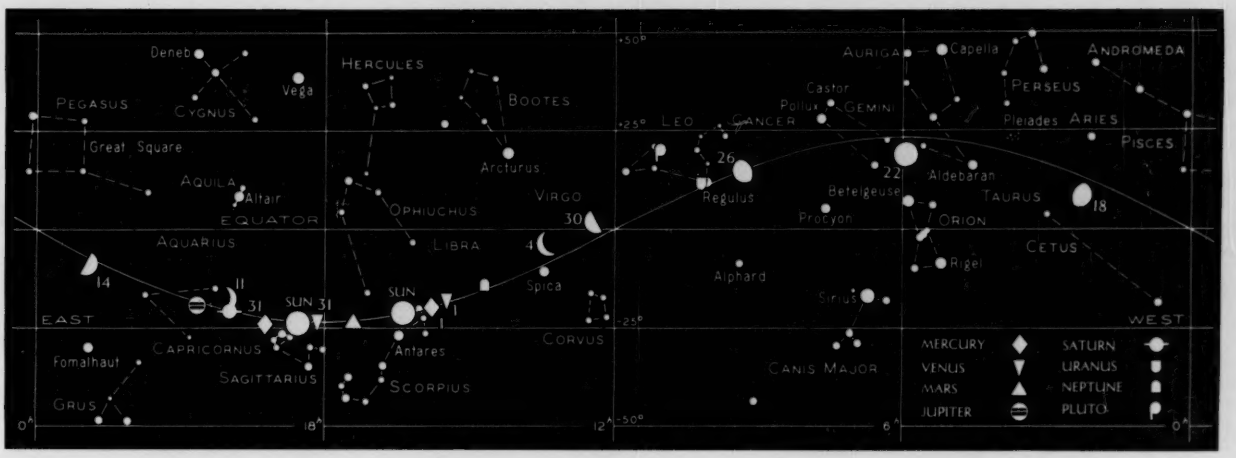


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0h Universal time on the respective dates.

Mercury is in superior conjunction with the sun on the 16th, and cannot be seen this month.

Venus is very low in the southeastern sky, rising about an hour before sunup during the first part of December. It is too close to the sun to be seen easily, however, and will be lost to view before the end of the month.

Earth reaches heliocentric longitude 90° at 2:20 Universal time on December 22nd, the time of the solstice. Winter begins in the Northern Hemisphere, summer in the Southern.

Mars arrives at superior conjunction on the 14th, and is too close to the sun to be seen all month.

Jupiter is a prominent yellow object of magnitude −1.6 in Capricornus, visible in the southwestern sky after sunset. The planet, which sets about 3½ hours after the sun at midmonth, has apparent polar and equatorial diameters of 32".1 and 34".4, respectively.

Saturn is in Sagittarius, almost 10° west of Jupiter, with a magnitude of +0.8 on the 15th. Telescopically, it shows a slightly flattened disk 15".4 in equatorial and 13".8 in polar diameter. The ring system, inclined 21°.8 to our line of sight, has a major axis of 34".8. The crescent moon will pass 2° north of Saturn and Jupiter on December 11th at 0h and 14h UT, respectively.

Uranus is a 6th-magnitude object in Leo, on the 15th at right ascension 10h 10m.8, declination +12° 04′ (1950 coordinates), about a degree east of Regulus. Rising some 2½ hours before midnight, Uranus is visible in binoculars. The moon passes 0°.3 north of this planet at 23h UT on December 26th, as seen from the center of the earth, and an occultation will be visible from Europe, North Africa, and Asia.

Neptune, an 8th-magnitude object, can be seen before dawn in Libra. On the 15th, its position will be 14h 41m.8, −13° 54′.

WILLIAM H. GLENN

DECEMBER METEORS

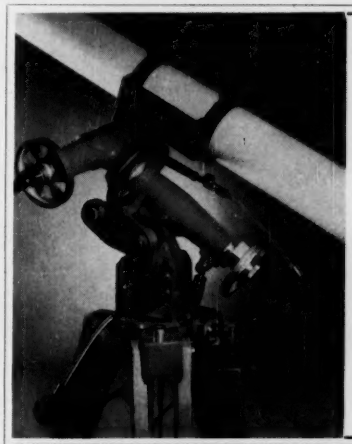
The first quarter moon may interfere somewhat with observations of the Geminids. At the peak of this well-known six-day shower, December 13th, a single observer can see as many as 50 meteors per hour under ideal conditions, about seven of these being nonmembers.

The Ursids will be very difficult to observe because of the full moon that occurs one day before the shower peak on December 22nd this year. Generally, this brief shower has a maximum rate of about 15 meteors per hour.

WILLIAM H GLENN

UNIVERSAL TIME (UT)

In the Celestial Calendar, Universal time (Greenwich civil time) is used unless otherwise specified. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown. For example, 6:15 UT on the 15th of the month corresponds to 1:15 a.m. EST on the 15th and to 10:15 p.m. PST on the 14th.



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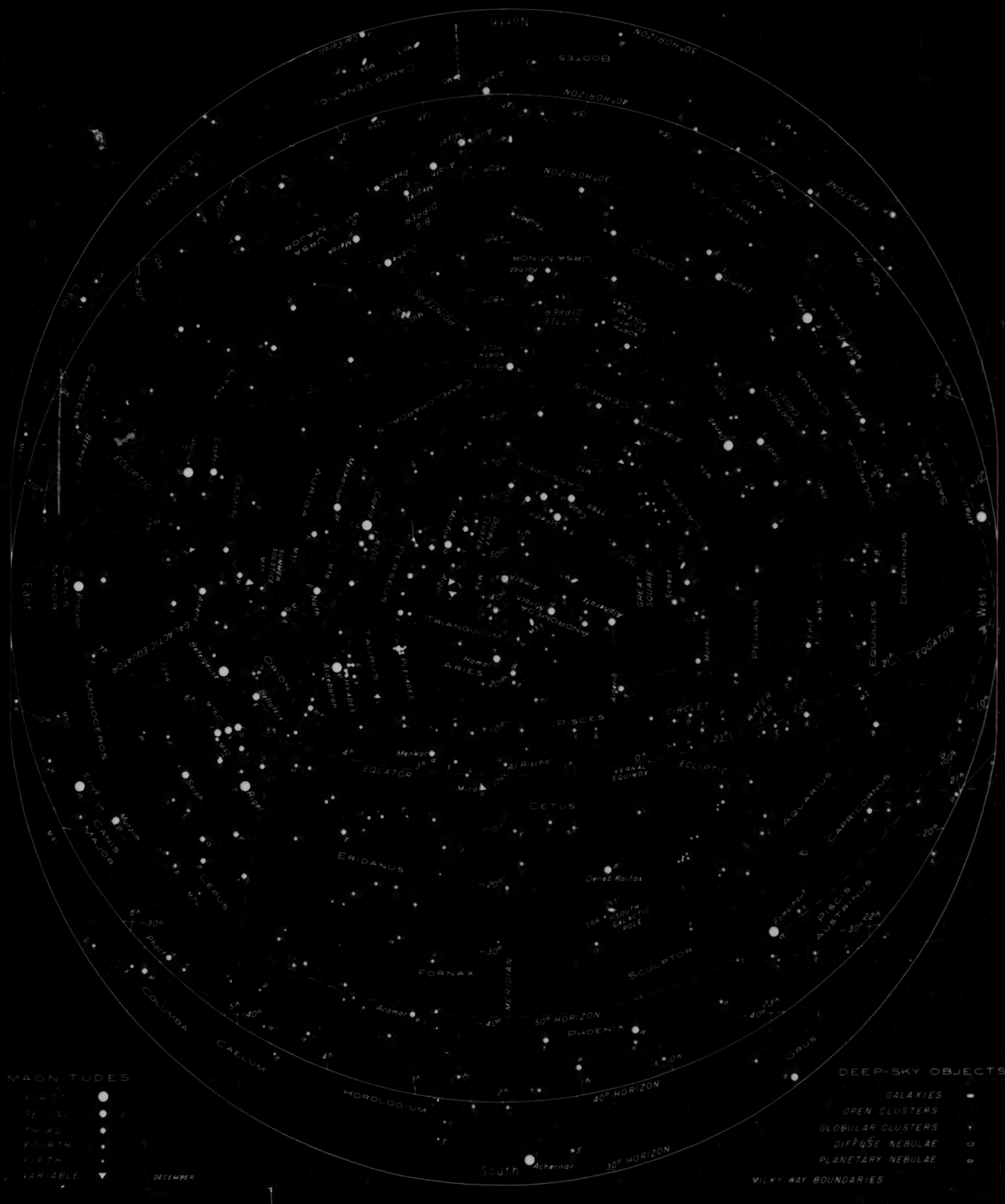

STARS FOR DECEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 6th and 22nd of December, respectively; also, at 7 p.m. and 6 p.m. on January 6th and 21st. For other dates, add or subtract ½ hour per week.

The stars of Triangulum, located between the Pleiades and Andromeda, are on the meridian at chart time. This small constellation was given much attention by the ancients. To the Greeks it was the capital letter delta, and because of its shape was likened to the island of Sicily.

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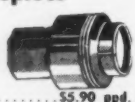

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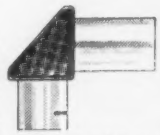

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30	61	2.7	7
40	49	2.0	4
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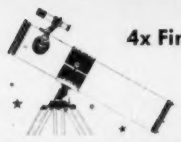
4" Reflector Telescope

45x-225x

4x Finder — Wood Tripod



Study the sun and its spots. Observe galaxies, clusters, nebulae, and the Milky Way. Enjoy the thrill of being able to pick out small craters on the moon and see detail in the larger craters. A beautiful lunar landscape is brought to your doorstep. Bring distant events close to you; witness nature in action — eclipses, heavenly objects, and orbiting satellites. A high-quality telescope with an f/9 mirror. It has three eyepieces, 4-mm. (225x), 6-mm. (150x), 20-mm. (45x), and a free Barlow lens which will double the power. This will give 90x with the 20-mm. eyepiece, and 300x with the 6-mm. if observing conditions permit. Equipment tray keeps eyepieces clean and at hand. Sun and moon filters are included. Collapsible wood tripod makes scope portable, gives it stability and compactness. Finished in gray enamel with black trim. Imported. Shipping weight about 20 lbs.

FREE BARLOW LENS PLUS FREE BOOK "DISCOVER THE STARS" come with scope.

Cat. No. $2273 ..... **f.o.b. Lynbrook, N. Y., $59.50**

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Cat. No.	Size	Field at 1,000 yards	Type	Price, ppd.
$1149	6 x 15 IF	360 ft.	Opera	$12.75
$1436	6 x 30 CF	395	"Zeiss"	18.75
$1435	6 x 30 IF	395	"Zeiss"	16.75
$1438	7 x 35 CF	341	"Zeiss"	20.75
$1437	7 x 35 IF	341	"Zeiss"	17.95
$1771	7 x 35 CF	341	American	23.50
$1439	7 x 35 CF	578	American*	35.00
$2191	7 x 50 CF	530	American**	42.50
$1106	7 x 50 CF	372	"Zeiss"	24.95
$-961	7 x 50 IF	372	"Zeiss"	22.50
$1503	7 x 50 CF	372	American	32.50
$1443	8 x 30 CF	393	"Zeiss"	21.00
$1229	8 x 30 IF	393	"Zeiss"	18.25
$1108	10 x 50 IF	275	"Zeiss"	26.75
$1442	20 x 50 CF	183	"Zeiss"	33.75

*Wide-angle 11° **Wide-angle

Add 10% Federal tax to all prices above.

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Cat. No. $1579 ..... 16 x 50 ..... **17.50 ppd.**
Cat. No. $1580 ..... 20 x 50 ..... **20.00 ppd.**

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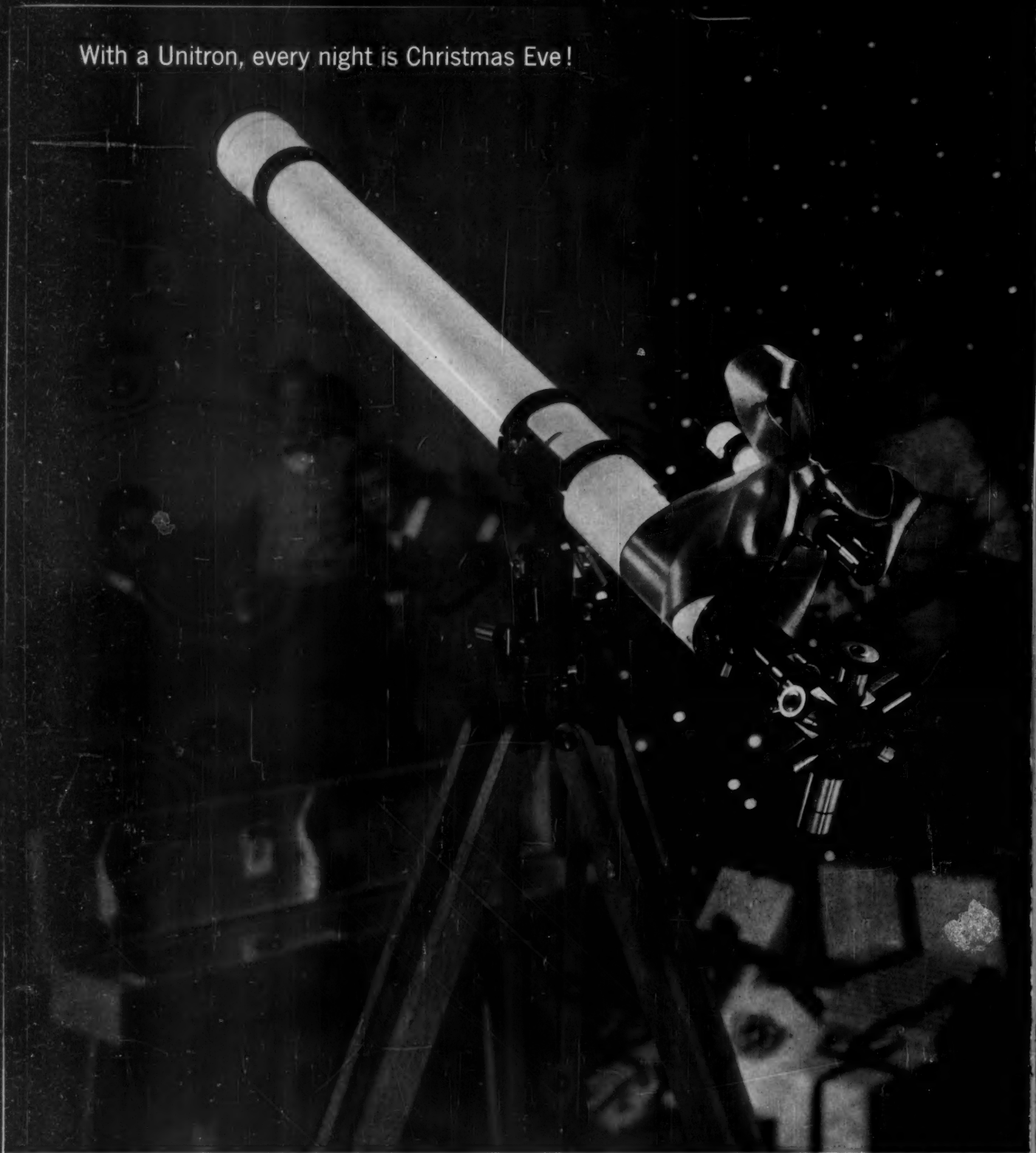

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As a matter of fact, there's more pleasure-per-dollar in the Unitron 3-inch Altazimuth you see in this picture (or in any other Unitron) than you can find in any refractor anywhere on this planet of ours. How do we know?

Santa Claus told us. He says that there are more Unitrons delivered at Christmas (and throughout the year) than any other refractors.

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SEE PAGES 364 AND 365 FOR MORE ABOUT UNITRON.